

**STATUS OF MINERAL RESOURCE INFORMATION FOR THE  
SAN CARLOS INDIAN RESERVATION, ARIZONA**

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## SUMMARY AND CONCLUSIONS

The San Carlos Indian Reservation has a wide variety of mineral resources. Although only sand, gravel, and peridot (gem quality olivine) currently are produced, known mineral resources on the reservation include fuels, metals, and nonmetals.

Known fuel resources are limited to coal and uranium. Coal occurs in the Deer Creek Coalfield, but the coal probably is of little value at the present time, owing to its high sulfur and high ash contents. Uranium occurs at several places, but only one deposit is known that may have economic potential. Several hot springs and geothermal areas also occur on the reservation, but little information about them exists. Only two small areas are thought to be prospective for oil and gas.

Metals that have been produced from reservation lands include gold, silver, lead, zinc, and copper. Iron and manganese also are known to occur, but apparently have not been produced commercially.

Nonmetallic resources on the reservation include asbestos, barite, diatomaceous earth, tuff (tufa stone), gypsum, olivine, garnet, guano, and sand and gravel. Current production is limited to gem quality olivine (peridot) by individual tribal members and to sand and gravel by both private producers and the Arizona State Highway Department. Based on value, probably more asbestos has been produced from the reservation than any other single commodity.

The San Carlos Reservation appears to have potential for the production of mineral commodities. It is surrounded on three sides by large mineral deposits that have yielded significant quanti-

ties of minerals, particularly copper, for 80 to 100 years. The reservation has not been explored in detail except possibly for asbestos. Development potentials of the reservation cannot be adequately assessed, however, prior to completion of a detailed field examination.

## INTRODUCTION

This report was prepared for the U.S. Bureau of Indian Affairs by the U.S. Geological Survey and the U.S. Bureau of Mines under an agreement to compile and summarize available information on the geology, mineral resources, and potential for economic development of certain Indian lands. Source material included published and unpublished reports, as well as personal communications. There was no fieldwork.

The San Carlos Apache Indian Reservation (population 5,979, BIA records, 1978) includes parts of Gila, Graham, and Pinal Counties in east-central Arizona ([Figure 1](#)). The reservation is an irregularly shaped area of 1,826,541 acres, all of which is tribally owned (BIA records, 1978). The Tribe owns the subsurface rights to the entire reservation except for some small areas that are held as mineral patents by non-Indians ([Figure 2](#)). Part of the reservation, the southwestern portion known as the mineral strip ([Figure 2](#)), was acquired by the Tribe only recently.

The reservation, located in the transition zone between the Colorado Plateau and Basin and Range physiographic provinces, is an area of rough topography drained by the Black and Salt Rivers in the north and the Gila River in the south.

The transportation network in and near the reservation is adequate. U.S. Highway 70 passes east-west through the southern part of the reservation. U.S. Highway 60 affords access to the westernmost part, and U.S. Highway 666, although east of the reservation, provides entry to the eastern part. County and BIA roads provide access to most of the remainder of San Carlos land. The Southern Pacific Railroad passes through the San Carlos Reservation and has sidings at the village of San Carlos. Transport facilities of the same railroad also are available just off the southwest corner of the reservation at Winkelman and Hayden, Arizona, and at Globe about 6 miles west of the reservation boundary.

Principal towns of the region are Globe (population 7,733), Miami (population 3,394), San Carlos (population 3,542), and Pima (population 1,184). Phoenix (population 581,562) is about 100 miles west of San Carlos, and Tucson (population 262,933) is about 110 miles southwest (U.S. Dept. Commerce, 1973).

The boundary between the Colorado Plateau and the Basin and Range physiographic provinces passes through the center of the reservation along a northwest-southeast line that roughly follows the escarpment of the Natanes Plateau (called Natanes Mountains on some maps; both terms are used in this report). In the Colorado Plateau province, the surface is typically a flat plateau underlain by relatively flat lying strata. In the Basin and Range province, broad basins lie between northwest trending block-faulted mountain ranges that have complex structures and gently to steeply tilted strata.

The climate is arid and there are only a few perennial rivers including the Salt River on the reservation's northern boundary, the Gila River which passes through the southern half of the reservation, and a few major tributaries to these rivers. San Carlos Reservoir provides irrigation water for the reservation.

The reservation lies near several of Arizona's major copper producing areas including the Globe-Miami, Lone Star, and Copper Mountain (Clifton-Morenci) districts and the Christmas mine.

## **Previous Investigations**

Geologic investigations of central Arizona began with the Wheeler expedition of the 1870's. During these expeditions Marvin (1875) and Gilbert (1875) provided details of the geology of the boundary between the Colorado Plateau and the Basin and Range provinces. Later, Darton (1925) and Wilson (1962) presented summaries of the geology and ore deposits of Arizona. Directly associated with the reservation are the studies by Schwennesen (1919), who examined the reservation's groundwater resources, and Bromfield and Shride (1956), who made a detailed study of the mineral resources on the reservation.

## **GEOLOGY**

Precambrian to Recent rock units occur within the reservation, but the most extensive units are Tertiary and younger volcanic flows in the plateau area and sedimentary rocks and unconsolidated sediments in the intermontane basins. The rocks that are mostly commonly associated with mineral

resources are predominantly the Precambrian Apache Group, Laramide intrusions, of which a few are known in the southwestern corner of the reservation, and the rocks which they intrude. The small scale of the geologic map (Figure 3) required many of the units to be combined, and the discussion below provides details not shown on the map.

## **Precambrian**

Precambrian units exposed within the reservation include (1) older Precambrian schist and granitic rocks, and (2) the younger Precambrian Apache Group and Troy Quartzite. Both the Apache Group and the Troy Quartzite consist of unmetamorphosed sedimentary rocks except where they have been intruded by younger igneous rocks. A major unconformity separates the older Precambrian from the younger Precambrian rocks.

## **Schist and Granitic Rocks**

Pinal Schist and granitic batholiths intrusive into it are exposed in the mountain ranges in the southwestern part of the reservation. The Pinal Schist consists of metasediments with a few meta-volcanic intercalations (Shride, 1967). In the Aravaipa mining district in the southern part of the reservation, the schist is a quartzitic schist interbedded with fine-grained quartz-sericite-chlorite schist (Wilson, 1950). The granitic batholiths that intrude the Pinal Schist show a variety of compositions from granite, quartz monzonite, and granodiorite in the southwestern corner of the reservation (Creasey and others, 1961), to granite and quartz diorite near Globe west of the reserva-

tion (Rubly, 1938), to granite and granodiorite near Clifton east of the reservation (Moolick and Durek, 1966). These plutons probably were emplaced during three intrusive cycles between 1,700 m.y. (million years) and 1,400 m.y. ago (Livingston and Damon, 1968; Silver, 1968).

## **Apache Group**

Rocks of the Apache Group are exposed in the southwestern one-third of the reservation. Shride's (1967) redefined stratigraphy of the Apache Group is used below. He divides the Apache Group from bottom to top into three units: the Pioneer Shale, Dripping Spring Quartzite, and Mescal Limestone.

## **Pioneer Shale**

The Scanlan conglomerate is 0 to 15 feet thick, locally arkosic, and composed of quartz pebbles in a matrix derived from the underlying rocks. It forms the basal member of the Pioneer Shale. The shale is 0 to 150 feet thick and consists of thin-bedded tuffaceous mudstone or siltstone with the coarsest beds being near the bottom of the unit. Gastil (1954) emphasizes the volcanic character of the tuffaceous mudstone and siltstone of the Pioneer Shale and thinks a thin deposit of ash was spread over a large area.

## **Dripping Spring Quartzite**

The Dripping Spring Quartzite has three members. The basal Barnes Conglomerate member is 0 to 50 feet thick, and is composed of well rounded quartzose pebbles and cobbles in a medium- to

coarse-grained feldspar-rich matrix (Granger and Raup, 1964). The middle and upper members have an aggregate thickness of 300 to 500 feet. The middle member is composed of medium-grained arkosic sandstones or orthoquartzites that are thin to thick bedded and often crossbedded. The upper member is a stratified sequence of thin-bedded, silty, finegrained, feldspar-rich rocks divided into red, gray, buff, and white units. The gray unit is important because it is locally a host for a strata-bound deposit of uranium.

### **Mescal Limestone**

The Mescal Limestone is 0 to 350 feet thick and includes three members. The lower member originally consisted of thin- to thick-bedded cherty dolomites that were later silicified. The middle member contains a lower stromatolite unit and an upper thin-bedded dolomite devoid of algal structures. Asbestos deposits are often found where diabase has intruded this member. The upper member is a siliceous argillite with lesser amounts of mudstone. Unnamed basalt flows locally overlie the Mescal Limestone and occur on Apache Ridge which extends into the western part of the reservation.

### **Troy Quartzite**

The Troy Quartzite is 0 to 400 feet thick, and unconformably overlies the Apache Group. Its three members include a basal arkose, the Chediski sandstone, and an upper quartzite (Shride, 1967). Near its base, the unit is conglomeratic. Medium- to large-scale crossbedding is common. The scar-

city of feldspar and a coarser grained texture help distinguish it from the Dripping Spring Quartzite (Bromfield and Shride, 1956).

### **Diabase**

The youngest Precambrian rocks are the diabase sills and dikes which intrude the Apache Group, the Troy Quartzite, and older Precambrian rock units. The sills range from a few inches to 1,000 feet thick, persist laterally, and usually do not cut across bedding. Thicker sills may have resulted from multiple intrusions. Numerous diabase dikes exist, but are small in volume compared with the sills. Most of the diabase is medium grained, although chilled margins are common and coarse-grained facies have been found. Pyrite and rarely chalcopyrite are locally found disseminated in the diabase. This unit, which is important to the asbestos and uranium mineralization, has been dated at 1,150 m.y. (Livingston and Damon, 1968).

### **Paleozoic**

With the exception of minor diabase intrusions, the Paleozoic is represented by numerous sedimentary formations that were deposited between erosional intervals, some of which were quite long. Several of these units, particularly the Pennsylvanian Naco Formation, are important host rocks for copper and other mineralization related to Laramide intrusive activity.

## **Cambrian**

### **Bolsa Quartzite**

Found only in the southwestern corner of the reservation, this unit is a partly crossbedded, poorly sorted, coarse- to fine-grained sandstone (Krieger, 1968). The coarser lower part contains angular fragments of the Troy Quartzite. Where it lies on diabase, the base is reddish-purple to grayish-red conglomerate. Elsewhere the unit is light colored.

### **Abrigo Formation**

Krieger (1961) noted that the Abrigo Formation is readily distinguishable from older sedimentary rocks by the presence of brachiopods, fucoid tubes, and tracks. This unit is also found only in the southwestern corner of the reservation. Both the Bolsa and Abrigo become thinner and sandier northward. The Abrigo includes three members: a lower member of mudstones, siltstones, and sandy mudstones; a middle member of poorly sorted, argillaceous sandstone with some conglomerates and shale partings; and an upper member of medium- to coarse-grained dolomite and dolomitic sandstone containing argillaceous and chert layers (Krieger, 1961). The basal member is transitional into the Bolsa Quartzite.

## **Devonian**

Although Ordovician strata have been reported near Clifton (Stoyanow, 1936), no Ordovician or Silurian rocks are found within the reservation.

## **Martin Formation**

The Martin Formation is exposed south of the Natanes Plateau in the mountain ranges of the Basin and Range province where it rests unconformably on the Troy Quartzite (Huddle and Dobrovolsky, 1952) and reaches a maximum thickness of 350 feet. In the Fort Apache Reservation to the north, Teichert (1965) defined a basal member, the Beckers Butte Member, consisting of shales, sandstones, and conglomerates, but it apparently thins out before it reaches the San Carlos Indian Reservation. The only member of the Martin Formation known to occur on the reservation is the Jerome member which contains, from bottom to top, a fetid fine- to medium-grained dolomite, an aphanitic dolomite with shale partings and detrital quartz and chert, a mottled dolomite, and diverse unit of dolomite, shale, and limestone (Teichert, 1965). Corals, brachiopods, and fucoids are abundant, with lesser quantities of crinoids, bryozoa, and mollusks. Where the Martin Formation is in contact with younger intrusive rocks, it frequently has been metamorphosed and locally exhibits copper mineralization.

## **Mississippian**

### **Redwall Limestone**

North of the Natanes Rim, mostly in the northwestern corner of the reservation, the Redwall Limestone overlies the Martin Formation (Bromfield and Shride, 1956). It is a medium-gray limestone containing chert nodules and is massive in the lower and middle portions. (Note: the

Natanes Rim is also called the Nantac Rim on some maps, including most of those in this report.)

### **Escabrosa Limestone**

The Escabrosa Limestone, 500 feet thick, is the equivalent of the Redwall Limestone south of the Natanes Plateau. It crops out primarily in the southwestern one-third of the reservation. The massive coarse grained limestone contains thin-bedded limestone, dolomitic limestone, and chert nodules. The base of the unit contains a coarse-grained sandstone and dolomitic sandstone in the Galiuro Mountains. Abundant fossils include crinoids, brachiopods, and corals (Krieger, 1968). Several local names for the Mississippian rocks have persisted in areas near the reservation including the Toronado Limestone in the Globe-Ray area (Ransome, 1916), the Modoc Limestone near Clifton-Morenci (Stoyanow, 1936), and the Tule Spring Limestone north of Morenci (Stoyanow, 1936). The Escabrosa Limestone has been mineralized in a manner similar to the Martin Formation.

### **Pennsylvanian**

#### **Naco Limestone**

This highly reactive limestone has served as an important host for the replacement ores of copper west of the reservation at the Christmas mine and several mines in the Globe-Miami district. The Naco Limestone at Christmas, outside the southwest corner of the reservation, is a nearly white, medium-bedded, fine-grained to porcellaneous limestone with yellowish-gray shales between the

beds. Fusulinid foraminifera abound in parts of the section. Basal beds near Globe (and possibly in the reservation) contain reddish shales (Peterson, 1962). The entire unit is 1,200 feet thick. Shaly, yellowish, limestone beds are common throughout the section but are particularly abundant in the upper part (Willden, 1964). It is these shaly impure limestones that have been particularly favorable for the copper mineralization.

### **Mesozoic**

Triassic and Jurassic rocks are absent in and near the reservation, and Cretaceous rocks are found only within the southwestern corner of the reservation. South of the reservation in the Klondyke quadrangle (see [Figure 9](#)), Cretaceous strata that have been termed the Pinkard Formation consist of gray and brown, fine- to medium-grained, clastic sediments with lesser amounts of conglomerate and calcareous sandstone. Graywackes, feldspathic sandstone, and quartzite plus siltstone and shale predominate (Simons, 1964). These may correlate with the unnamed sandstones, shales, and conglomerates in the Reed Basin area of the reservation in which coal measures have been found.

Unnamed volcanic units including agglomerates, tuffs, flows, flow breccias, and sedimentary rocks overlie the sedimentary unit (Willden 1964).

### **Laramide (Cretaceous-Tertiary)**

The Cretaceous-Tertiary transition was a period of intrusive activity intimately related to copper mineralization. The major copper districts near San

Carlos have granitic intrusions of intermediate to silicic composition; some of them are porphyritic. Small Laramide stocks occur in the southwestern corner of the reservation. Also during this time, unnamed sedimentary and volcanic units were deposited.

## **Cenozoic**

Extensive volcanism began in the Tertiary and continued into the Quaternary. Large extensive flows accumulated in the Colorado Plateau province to a thickness of 1,000 feet, while less-extensive volcanics erupted to the south. Intrusive activity waned, although Creasey, Jackson, and Gulbrandsen (1961) mapped a Tertiary rhyolite intrusive, and Quaternary basaltic plugs are displayed on the Gila County geologic map (Wilson and others, 1959). Also at this time, sediments began to accumulate in the intermontane basins of the Basin and Range province. Most of these units have not been named.

## **Tertiary**

### **Whitetail Conglomerate**

Clasts in the conglomerate were derived from the units directly underlying it; thus its composition is determined by the unit upon which it rests. The Whitetail Conglomerate was deposited in low-lying areas and is discontinuous but can be found in many places throughout the southwestern part of the reservation.

### **Galiuro Mountain Volcanics**

These Tertiary volcanic units, found primarily in the Galiuro Mountains in the southern part of the reservation, include a variety of andesite flows, tuffs, conglomerates, and some latitic flows (Krieger, 1968).

### **Gila Conglomerate**

The Gila Conglomerate occurs mostly in the southwestern one-third of the reservation and drapes most of the mountain ranges, sometimes to a thickness of 700 feet. It consists of particles ranging in size from sand to boulders (Schwennesen, 1919) that tend to be angular on mountain slopes and more rounded and better sorted toward valleys.

### **Other Tertiary Units**

Unnamed sedimentary gravels underlying the Natanes Plateau are thought to be older than the Gila Conglomerate. These gravels contain Apache Group detritus which indicates a southern source rather than an origin from the Colorado Plateau (Bromfield and Shride, 1956).

Older Tertiary volcanics include basalt, rhyolite, and andesite flows and tuffs in the Gila Mountains and andesite flows along the Natanes Plateau. Younger flows are typically basaltic, including the extensive flows north of the Natanes Rim. Some of them may be related to the basalts of the White Mountains area (Merrill and Pewe, 1977).

The Gila and San Carlos basins were former lake beds in which sandstones, tuffs, and marly

clays accumulated. The strata dip slightly toward the centers of the basins (Schwennesen, 1919). Recent alluvial deposits can be found near some of the larger streams.

At Peridot, on the reservation, and in the Copper Creek mining district and Safford Basin, south of the reservation, are found basaltic plugs, diatremes, and plugs containing ultramafic nodules, all of which intrude Cenozoic volcanic and sedimentary units. In the Copper Creek area there are more than 100 pipes, usually elliptical in outline with a large vertical extent, but decreasing in diameter with depth. The pipes are more resistant to weathering than the country rocks. The breccia fragments are angular to rounded, 1 inch to 50 feet in diameter. Cement constitutes 5 to 50 percent of the breccia and includes quartz, sericite, chlorite, tourmaline, and sulfides (Kuhn, 1941). Several diatremes associated with basaltic plugs located in the lower Safford Basin have intruded basin sediments. They are similar to the diatremes of the Navajo-Hopi area (Marlowe, 1960) and all but two align north-south, but Marlowe (1960) indicates that there may be other diatremes undiscovered beneath the pediment surface. This may also be true of the plugs in the reservation.

The San Carlos Volcanic field includes basalt flows that cover parts of the lakebed sediments and several diatreme like vents. Peridot Mesa is one of these vents. Eruption began as an explosive vent clearing followed by pyroclastic surges. Less explosive lava flows followed and finally lava plugged the vent and the vent collapsed (Wohletz, 1978). Basalt from this vent contains numerous ultramafic nodules (predominantly spinel ilmenite) commonly 10 cm in diameter but as

much as 50 cm in diameter. These ultramafic nodules may have been derived from the upper mantle, from which the basaltic magma formed (Holloway and Cross, 1978).

## Structural Geology

The Basin and Range and Colorado Plateau physiographic provinces also define two structural provinces, both having complex histories. Bromfield and Shride (1956) define the Colorado Plateau in the reservation as everything north of the south rim of the Nantex Plateau, but the transition zone to the Basin and Range province is several miles wide. The Colorado Plateau had a complex history in the early Precambrian as seen in the granitic and metamorphic basement, but the overlying sedimentary series is flat lying and relatively free of faults. These dip gently under the extensive lava flows that cap most of the plateau in the reservation. Feth (1954) concludes the plateau uplift that formed the Mogollon Rim and Nantex Rim continues today, as evidenced by continuing earthquake activity. He further indicates that this structural zone probably first became active in the Precambrian. The rim area is important to water resources because springs at the contacts of the Apache Group and diabase provide some of the water to the reservation.

In the Basin and Range province layered strata are highly faulted and tilted at varying angles. The major faults trend parallel to the mountain ranges, a few of which were large enough to depict on [Figure 3](#). These faults are related to the formation of the Basin and Range in which the mountain ranges were block faults and resulting valleys filled

with thick alluvial material. Faulting also accompanied Laramide intrusions and is important to some of the mineralization in that it provided channels through which mineralizing solutions moved. Older faulting of the Apache Group related to the diabase intrusions is important in the formation of uranium occurrences in the Dripping Spring Quartzite and the asbestos occurrences in the Mescal Limestone.

## MINERAL RESOURCES

Known mineral resources of the San Carlos Indian Reservation include fuels as well as metals and nonmetals. Fuel resources occurring on the reservation are limited to coal and uranium. Small quantities of coal were produced around the turn of the century, but no records exist of uranium production from reservation land. The area also is known to contain geothermal resources, but neither oil nor gas has been discovered on or near the reservation.

Metallic resources include gold, silver, lead, zinc, copper, iron, and manganese. All the metals, except iron and manganese, apparently have been produced in the past, at least in minor quantities, but there is no current metal production. Antimony is described in ores of two or three mines, but its occurrence probably is more of academic than economic interest.

Nonmetallic resources include asbestos, barite, diatomaceous earth, tuff (tufa stone), gypsum, olivine (peridot), garnet, guano, and sand and gravel. Current production is limited to peridot and sand and gravel. However, asbestos, tufa stone,

and perhaps barite have been produced in the past. Garnet is collected illegally by rock hounds.

## Fuel Resources

Mineral fuel resources on San Carlos land are limited to uranium and coal. Uranium is not known to have been produced, but coal was produced in limited quantities near the turn of the century. The area contains some hot springs, but the potential for geothermal development is unknown.

Small areas on the reservation may be prospective for oil and gas exploration.

## Coal

Coal on the San Carlos Reservation is confined to the small Deer Creek Coalfield, which is described by Campbell (1904, p. 242) as being 10 or 12 miles long by 3 or 4 miles wide in a small synclinal basin between the Mescal Mountains and the ridge between Deer and Ash Creeks (Figure 4). Peabody Coal Co. investigated the area and described the field as 6 to 8 miles long and 4 to 6 miles wide (BIA files). No exact description of the Deer Creek Coalfield could be found, but, generally, it is located in T. 5 S., Rs. 16, 17 E. Some of the better quality coal in the field is on patented land in secs. 21, 22, and 23, T. 5 S., R. 17 E.

The best available description of the coal in the Deer Creek Coalfield is by Campbell (1904). The coal in the field may occur in several beds, but Campbell (p. 257) suggests that the coal is in two beds ranging in thickness between 24 and 30 inches. Peabody Coal Co., however, indicates that the coal ranges between 2 inches and 6 feet thick

(BIA files). Peabody Coal Co. had not submitted its findings to the Tribe at the time of this report; therefore, the complete results of the Peabody work are not known. Campbell (1904) describes the coal as having a high ash content, 18 to 54 percent, and a fixed carbon content ranging between 19 and 26 percent. Still, most of the coal will coke, and its coking properties were evidently the main reason for the development in the field early in the century.

## Development

Development of the coal may have begun shortly after discovery in 1881, but according to Ross (1925, p. 116) only desultory development was carried out until about 1896 when the reservation boundary was shifted north, thus allowing the earlier claims to be legally acquired. Ross states that after 1896 the area experienced considerable activity, and several small shipments of coal were made to Globe, Arizona. By 1907 all activity had ceased, and, as far as could be ascertained, no coal has been produced since. In 1925, when Ross investigated the area, all mine openings were caved and much of the evidence of past development had been obliterated, but he indicated that "a number of slopes, pits, and shafts were sunk."

## Reserves

Little is known of actual coal reserves in the Deer Creek Coalfield, but Campbell (1904) estimates that as much as 60 million tons of coal may occur in the field, of which about 30 million may be recoverable. Campbell based his calculations on

a bed 2 feet thick covering an area of 30 square miles. The investigations by Peabody Coal Co. estimated the total area to be between 24 and 48 square miles and underlain by beds up to 6 feet thick. Therefore, considerably more coal may be present in the field than was estimated by Campbell. However, the coal is of poor quality (high ash-high sulfur content) and may not be minable under modern specifications and environmental concerns.

## Uranium

Uranium is known to occur on San Carlos land, but no production has been recorded. Probably the most important exploratory effort to date was by Urangesellschaft U.S.A., Inc., which conducted a small drilling program on the reservation in 1978-1979. Phillips Minerals is conducting an exploration program just across the southern boundary of the reservation, and the company is purchasing drilling water from the Tribe.

An area underlain by the Dripping Spring Quartzite has received much attention in the past. Off the reservation this formation is known to contain many occurrences of uranium and has yielded some production.

Although the Dripping Spring Quartzite occurs near the surface in the northwest corner of the reservation ([Figure 4](#)), no uranium has been found inside reservation boundaries. A few deposits exist near but outside the reservation.

The exploration effort of Urangesellschaft that was carried out in 1978-1979 proved uranium mineralization in T. 2 S., R. 20 E. ([Figure 4](#)). The company drilled nine holes and encountered

uranium mineralization in six. The mineralized zone, ranging between .0004 percent and .0045 percent, was in tuffaceous, limey siltstone that contained carbonaceous material. Analysis of surface samples of the same area yielded results of .078 percent. It was believed by company personnel that the disparity between the values might have been due to dilution in the drill samples. According to Urangesellschaft, uranium mineralization occurred over an area of at least one-half square mile and at depth as well as near the surface. Company personnel believe that only additional drilling can determine the full extent of the mineralized area and the economic feasibility of mining the deposit.

Bendix Field Engineering Corp. awarded a contract to Texas Instruments Corp. (1978, p. N-4) to perform an aerial radiometric survey of part of the reservation. The aerial reconnaissance showed 11 anomalous areas in the southern part of the reservation (Figure 4). It reported that these areas are potential prospects.

It is known that the San Carlos Reservation contains significant uranium resources, but the figures concerning quantity of the mineral present must await an extensive drilling program to both delineate and quantify reserves. It appears reasonable to believe, however, that an economic or near economic resource may be present in T. 2 S., R. 20 E. Likewise, the area underlain by the Dripping Spring Quartzite may contain uranium resources.

### **Geothermal Energy**

Geothermal resources are known to occur on the San Carlos Reservation, but apparently have

not been tested at depth. Witcher (1979, p. A-23) shows a geothermal well or spring in sec. 17 or 18, T. 3 S., R. 18 E., but does not give a temperature. Alto and others (1979) show a geothermal well or spring in the same locality having a temperature of 97°F. They also show a geothermal area on either side of the San Carlos River covering several sections (Figure 4). One temperature of 85°F is given for a spring or well in this area. Another spring with a temperature of 97°F is shown at Coolidge Dam and another spring of 99°F is shown near the western boundary of the reservation. The same authors also show a geothermal area in the northern part of the reservation along the Salt River in T. 4 and 4½ N., R. 20 E. Two springs or wells within this area, but off the reservation, have temperatures of 65° and 83°F.

The full development potential of the geothermal areas on the reservation cannot be evaluated prior to an intensive exploration program. Nevertheless, the temperatures given for the area by Alto and others, and by Witcher, indicate that water or heat from the areas possibly could find use for space heating or various agricultural or industrial applications, such as drying grains, commercial greenhouses, and drying manufactured goods that require such a process.

### **Oil and Gas**

Neither petroleum nor natural gas has been discovered on reservation land. Stipp (1960) rates two small areas on the reservation as prospectively valuable for oil and gas. One area includes parts of Tps. 3, 4, 5 S., R. 22 E., and the other includes parts of T. 4 N., Rs. 20, 21 E. (Figure 4).

## Base and Precious Metals

Base and precious metals have been produced in the past from within the reservation. Apparently most of that production came from mines in two recognized mining districts. According to BIA personnel, however, evidence of prospecting and mining occurs outside the mining districts. Furthermore, the Bureau of Land Management (BLM) invalidated several thousand mining claims on that part of the reservation, in and near the mining districts, that recently was acquired by the Tribe. This area is called the "Mineral Strip" and is shown on [Figure 2](#) and [Figure 5](#). Therefore, it is possible that base and precious metals have been produced from deposits on the reservation but outside the mining districts. Moreover, gold is known to occur in gravels of the Gila River immediately adjacent to the southeast corner of the reservation and may occur in Gila River gravels on the reservation. Iron and manganese also have been found in areas outside the recognized mining districts. The American Oil Co. (AMOCO) recently secured a permit from the Tribe to investigate the surface geology of 213,120 acres of San Carlos land in Ts. 1, 2, and 3, N. and S., Rs. 17, 18, and 19 E.

### Saddle Mountain Mining District

The Saddle Mountain mining district is located on both sides of the west boundary of the reservation near the southwest corner ([Figure 5](#)). The major operation is the Christmas Mine, which is about 1 mile west of the reservation boundary and has produced ore since 1903. The mine originally

was on the reservation, but that part of the reservation was declared public domain in 1902. Other mines and properties in the district that are within the present reservation boundaries include the Adjust Mine, Saddle Mountain Group, Little Treasure Mines, Lee Group, Carmichael Group, Two Queens Mine, Pool's Mine, and Faull Group.

### Adjust Mine

The Adjust Mine is in secs. 34 and 35, T. 4 S., R. 16 E. ([Figure 5](#)). According to Ross (1925, p. 41-43), the mine was operated both before and after 1922. The only production figures available show that 640 tons of oxidized ore was shipped prior to 1922. Ross does not give the extent of the workings at the property but states that the property consists of 13 claims "on which there are a number of shafts, adits, and cuts," and that there were, in 1922, about 1,500 feet of workings on the principal vein. The vein is in Cretaceous andesite cut by small dikes of quartz mica diorite. Minerals produced included galena, sphalerite, chalcopryite, bornite, gold, and silver in addition to the gangue minerals pyrite, limonite, quartz, barite, and calcite. Ross also states that the gold and silver apparently are contained in the galena, pyrite, and sphalerite. Silver values ranged between 30 and 250 ounces per ton. Gold values were about 0.15 ounce per ton.

### Saddle Mountain Group

The description of the Saddle Mountain Group of 15 patented and unpatented claims given by Ross (1925) does not include legal location data.

Ross does indicate, however, that the property is southeast of the Adjust Mine and that the Saddle Mountain Group is on the ridge between Ash and Deer Creeks. This location is probably in sec. 2, T. 5 S., R. 16 E. In 1922, when Ross visited the property, mine workings totaled 3,450 feet, but no more than a few hundred feet were in any one place on the property. The country rock is reported to be Cretaceous andesite and andesitic breccia. A long dike ( $\frac{3}{4}$  mile) of quartz mica diorite is on the property, and the exposed vein parallels the dike. The dike is described by Ross as having been mineralized over part of its extent.

Total production from the property is unknown, but Ross states that both oxide and sulfide ores were shipped and that the smelter returned between \$30 and \$120 per ton.

In addition to gold and silver, lead, zinc, and copper were produced from the minerals galena, sphalerite, and chalcopyrite. Ross lists the oxide minerals of the same elements in the mine as anglesite, cerussite, and chrysocolla. Other minerals present include gypsum, pyrite, quartz, and various iron oxides.

### Little Treasure Mine

The Little Treasure Mine is a series of six unpatented claims in the SE $\frac{1}{4}$  sec. 35, T. 4 S., R. 16 E. and NE $\frac{1}{4}$  sec. 2, T. 5 S., R. 16 E. (Figure 5). Ross (1925) states only that a few carloads of ore had been shipped by 1922 and that development on the property consisted of two tunnels, 240 and 150 feet long, and a shaft about 55 feet deep. All workings are in veins in a massive black basalt of Cretaceous age. Apparently, by 1922, all oxide

ores had been mined and only sulfide minerals remained. Ross lists the sulfides as galena, sphalerite, argentite, and possibly pyrrargyrite. Wire silver also was noted. Gangue minerals listed by Ross include barite, pyrite, quartz, and calcite.

### Two Queens Mine

The Two Queens Mine is in the SW $\frac{1}{4}$  sec. 3, T. 5 S., R. 16 E. (Figure 5). Ross (1925) describes the property as consisting of nine unpatented claims, together with mine workings comprised of a 260-foot shaft and two 100-foot crosscuts. Other workings include a 400-foot tunnel and a 90-foot winze, and several shallow shafts. According to Ross, the Cretaceous country rock includes sandstone, shale, andesitic lava, flow breccia, and tuff. The mineralization appears to have been a replacement in sedimentary strata.

Ross states that three small lots of ore that returned \$36.53 per ton were shipped between 1906 and 1908. Other information about the mine is sparse, but Ross states that a winze below the shaft bottomed in "sulfide ore carrying \$16 in gold and 10 percent copper."

### Pool's Mine

Pool's Mine is in secs. 3 and 4, T. 5 S., R. 16 E. Apparently, part of this property is on the reservation (Figure 5). Ross (1925) reports that in 1922 workings on the property totaled 600 feet, but it is unknown how much of it is on Indian land. Ross describes the main workings as being in a sheeted zone on a contact between andesite and slate. Other workings are described as being in the

Toronado Limestone. The mine was worked for copper and gold, but no production figures or ore values are given. According to Ross, minerals in the mine consist of partially oxidized pyrite and chalcopyrite with some malachite, fluorite, and oxides of iron.

### **Faull Group**

Only part of the Faull Group is on the reservation. Ross (1925) reports that at the time of his visit to the area, assessment work was in progress. Because of the indefinite location of this property, it is not shown on [Figure 5](#). Ross indicates that the only mineral he observed was pyrite in a tunnel driven into Cretaceous andesite. Apparently, the property has had no production.

### **Reserves**

Whether reserves exist in any of the mines in the Saddle Mountain district is unknown. Likewise, the reason for discontinuing the operations in the area is unknown. It may have been because the price of metals during the 1920's was low--gold around \$20 per ounce, silver less than \$1 per ounce, and copper, lead, and zinc only a few cents per pound. It is also possible that mining ceased owing to a lack of ore or because property ownership was clouded, the land having originally belonged to the San Carlos Indians who were supposed to draw a royalty from all minerals recovered. At any rate, the district should be investigated to determine whether the deposits contain minable ore reserves.

### **Stanley Mining District**

The Stanley mining district is located on and near Stanley Butte in the south-central part of the reservation ([Figure 5](#)). The Aravaipa mining district, which is off the reservation, adjoins the Stanley district to the south. The Deer Creek Coalfield lies adjacent to the Stanley district on the west and lies between the Stanley district and the Saddle Mountain district.

According to Ross (1925, p. 105-114), who investigated the district in 1922, the district contains 12 mines and prospects. The major property was the Starlight Mine that may have produced ore as far back as Spanish days. Deposits in the district yielded silver, lead, zinc, and copper. Ross reports gold at only one property in the district, the Copper Reef Mine. Ross also reports that antimony occurs on two properties. Others, however, report gold was recovered from Starlight Mine ores.

### **Starlight Mine**

The Starlight Mine has been the major mineral producer in the Stanley mining district. It is in the SE $\frac{1}{4}$  sec. 11, SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 12, NW $\frac{1}{4}$  sec. 13, and NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 13, T. 4 S., R. 19 F. ([Figure 5](#)). The mine was probably first worked by the Spanish and was rediscovered, according to Ross (1925), in 1886. The property now consists of 12 patented claims. Total production from the mine is unknown, but in 1905 and 1906 the deposit yielded 125,000 pounds of copper valued at about \$22,700. The Starlight Mine was operated in 1942, 1947, and 1956 (Foster, 1943, 1948; Massey, 1956). Production is not given, but metals produced were

gold, silver, copper, and lead. Wilson (1950) also lists a "small" production from the Starlight Mine in 1947. Ross (1925) does not discuss development on the property, but the San Carlos Reservoir 15-minute topographic map shows two shafts and two adits on the property. The condition of the workings is unknown. Ross states that "The deposits appear to be entirely in the Toronado Limestone." He states that Cambrian and Precambrian metamorphic rocks are also present.

When Ross visited the property in 1922, the workings probably were inaccessible because he reports ore from the mine dump but does not describe anything underground. He states that the copper minerals azurite, chrysocolla, and malachite, and the lead minerals anglesite, cerussite, and galena, were found on the dump but presents no analyses. The potential of the property is unknown.

### **Copper Reef Mine**

The Copper Reef Mine is on the section line between secs. 28 and 29, T. 4 S., R. 19 E. (Figure 5). The property is made up of 125 unpatented claims and a 600-acre mill site. Ross indicates that the workings consist of a 1,400-foot tunnel, a 1,000-foot drift, and a 735-foot shaft, all in the Toronado Limestone. He also reports some winzes and "a little stoping" off the drift. Ross states that both copper and lead ore have been shipped from the property, but he presents no data on the quantity or value of the material shipped.

According to Ross, mineralization included both sulfides and oxides and the minerals were barite, iron oxides, manganese oxide, chrysocolla,

malachite, chalcocite, chalcopyrite, pyrite, bornite, azurite, and a complex mixture of copper and iron oxides called copper pitch. Ross reports the ore averaged 5.4 percent copper and 68 percent silica and contained some silver and gold.

### **Friend Mine**

The Friend Mine is in the SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 34, T. 4 S., R. 19 E. (Figure 5). Ross (1925, p. 110) does not estimate how much land was involved at this mine, but he does report about 2,000 feet of underground workings. One tunnel is said to be 1,400 feet long, in addition to other short tunnels and shafts. The country rock is sandstone, shale, and andesite, and the veins appear to be in the andesite. At the time of Ross's visit, one carload and a few small lots of ore had been shipped from the property. The carload was copper carbonate. It is unknown whether ore was shipped from this property after 1922. Minerals reported include azurite, malachite, cuprite, bornite, chalcocite, chalcopyrite, hematite, and calcite.

### **Princess Pat Mine**

The Princess Pat Mine may be just over the south boundary and off the reservation. Ross (1925) says only that the property is made up of 44 unpatented claims just south of Stanley Butte. The San Carlos Reservoir 15-minute topographic map shows a mine in the SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 13, T. 5 S., R. 19 E. (unsurveyed). Because of the indefinite location of this property, it is not shown on Figure 5. Ross reports a total of 1,060 feet of underground workings, plus other workings of small extent

scattered over the property. Although Cretaceous andesite, sandstone, shale, and rhyolite all occur on the property, the mineralized zone is in andesite. The only known ore shipment from this mine before 1925 was one ton of oxidized copper ore. The state mine inspector, however, notes that the mine produced copper in 1959 and 1961 (Hersey, 1959). Production figures are not given. According to Ross, minerals include pyrite, limonite, malachite, sphalerite, galena, chalcopryrite, chalcocite, and calcite.

### **Copper Dike Group**

This property, as described by Ross, consists of 14 unpatented claims adjoining the Princess Pat Mine on the north. Therefore, if the Princess Pat Mine is off the reservation, it is possible that this prospect is off the reservation also. The Copper Dike Group is not shown on [Figure 5](#). At the time Ross visited the mine, only assessment work had been done. Mineralization occurred in two shear zones in andesite breccia. The only mineral mentioned by Ross is azurite. Development after 1922 is unknown.

### **Cold Spring Prospect**

The exact location of this prospect is uncertain. Ross says only that it is "somewhat less than 3 miles southeast of Stanley." The community of Stanley no longer exists, but it was in sec. 35 or 36, T. 4 S., R. 19 E. This property is not shown on [Figure 5](#). Ross reports a tunnel in Toronado Limestone on the property and states that the mine dump contained small amounts of stibnite,

sphalerite, chalcopryrite, and perhaps other copper sulfides.

### **Soldier Prospect**

The exact location of this prospect also is uncertain. Ross (1925) states that it is on the west side of Limestone Mountain about 1 mile east of Stanley. Limestone Mountain is in the SW $\frac{1}{4}$  sec. 31, T. 4 S., R. 20 E. ([Figure 5](#)). Development in 1922 consisted of an inclined shaft more than 1,000 feet long in the Toronado Limestone. Copper stain (probably malachite), garnet, hematite, and quartz are minerals mentioned as occurring at the prospect.

### **Copper Bell Mine**

This property is described by Ross (1925) as being a short distance west of Stanley. It is not shown on [Figure 5](#). The property was developed by several shallow shafts, and two partial carloads of ore are reported to have been shipped. According to Ross, the deposit is in highly faulted Toronado Limestone. Minerals include hematite, calcite, pyrite, and chalcopryrite.

### **Silver Spar Prospect**

This prospect is described by Ross (1925) as being on the west side of Stanley Butte near the top. The top of Stanley Butte is in the NE $\frac{1}{4}$  sec. 11, T. 5 S., R. 19 E. ([Figure 5](#)). Development in 1922 consisted of a short tunnel and shallow shaft in a dark latite or andesite breccia. Mineralization is in irregular seams made up of quartz, barite, and

fluorite. Ross was unable to identify the ore minerals, but he believed them to contain silver, lead, antimony, and copper. This property may be the same as the Barium King Group described by Stewart and Pfister (1960). The Barium King Group is described in this report in the section on nonmetallic minerals.

### **Stanley Mine**

This property may be only a prospect. It is listed by Ross (1925) as being "a little over a mile east of Stanley." It is not shown on [Figure 5](#). The principal development is a tunnel, thought to be 1,200 feet long, in red Cretaceous sandstone. The tunnel did not reach the intended structure. No description of mineralization was given by Ross. Wilson (1950) lists a small lead ore production from the Stanley Butte property in 1947 but does not give the tonnage.

### **Prospects on Rawhide Mountain**

Little is known of these prospects. Ross (1925) reports that silver was found in the Toronado Limestone and that a short tunnel was driven in that formation southwest of Rawhide Mountain. The summit of Rawhide Mountain is in the NE¼ sec. 36, T. 4 S., R. 18 E. The San Carlos Reservoir 15-minute topographic map shows a shaft and adit southwest of the mountain in the same section, but it is possible that those workings are in coal rather than limestone. This property is not shown on [Figure 5](#).

### **Parks Brothers Prospect**

Information concerning this prospect is sparse, but Ross describes it as being just upstream from the Starlight Mine. The San Carlos Reservoir 15-minute topographic map shows an adit at that location in sec. 11, T. 4 S., R. 19 E. Ross (1925) reports a tunnel on the property in chloritized felsite containing a little pyrite.

### **Reserves**

As in the Saddle Mountain mining district, it is not known whether mining was discontinued in the Stanley mining district because of low metal prices or the low tenor of the ore, or both. No reserve figures for the district exist. Therefore, prior to a field investigation, it is not possible to predict the economic potential of the area.

### **Other Mining Claims Outside the Recognized Mining Districts**

Several mining claims have been staked on the reservation outside the established mining districts. The Bureau of Land Management (BLM) investigated and invalidated virtually all such claims; court proceedings, however, did prove evidence of mineralization. Therefore, the claims for which locations are known are included in this report. In addition to those claims listed here, many others were located in the mineral strip ([Figure 2](#) and [Figure 5](#)), and the BLM invalidated more than 7,500 of them. Most of the invalidated claims were the same locations that had been staked time and again; others were obtained by ranchers who

located mining claims both on available water and mineral occurrences, often for the purpose of keeping prospectors and others off the land.

### **Brushy Spring Claim**

This location is in SW $\frac{1}{4}$  sec. 11, T. 5 S., R. 19 E. (Figure 5). It may have been located for water by the rancher who owned the surrounding land. The BLM geologist who investigated the claim stated that there is no evidence of prospecting or mineral exposures on the claim.

### **Christina Claim**

A prospect tentatively listed as the Christina Claim was visited and sampled by BLM geologists in 1972. The property is located in NW $\frac{1}{4}$  sec. 35, T. 4 S., R. 19 E. (Figure 5). The workings consisted of two shallow shafts about 40 and 25 feet deep in limestone. According to the BLM geologist, mineralization was slight and was comprised of pyrite, calcite, malachite, and iron oxides. A sample assayed only 0.10 ounce of silver and no gold. It is not known whether the sample was assayed for base metals.

### **Refuge Group**

The Refuge Group is a series of five claims (Refuge No. 1, 2, 3, 4, and 7) in secs. 23, 24, 25, and 26, T. 4 S., R. 20 E. (Figure 5). The claims were visited by BLM geologists in 1972 and later were declared invalid by the courts.

Refuge No. 1. This claim is in the SE $\frac{1}{4}$  sec. 23, T. 4 S., R. 20 E. Development consists of an

inclined adit in an andesite or rhyolite dike that intruded andesite. Both malachite and azurite were visible in the adit at the time of the visit. A sample assayed 0.2 ounce of silver and 1.45 percent copper per ton.

Refuge No. 2. This claim adjoins Refuge No. 1 on the west and is also in SE $\frac{1}{4}$  sec. 23, T. 4 S., R. 20 E. The occurrence is opened by an inclined adit and a shallow cut in the same structure as Refuge No. 1. A sample taken at the time of the visit assayed 0.05 ounce of silver and 0.95 percent copper per ton.

Refuge No. 3. This claim adjoins Refuge No. 2 on the west and is in secs. 24 and 25, T. 4 S., R. 20 E. It is opened by an adit and a shallow open cut. Chalcopryite was observed in shears in the andesite country rock. An assayed sample showed a trace of silver and 0.47 percent copper.

Refuge No. 4. The Refuge No. 4 claim adjoins Refuge No. 3 on the west. It is in secs. 24 and 25, T. 4 S., R. 20 E. Development consists of a 30-foot adit in what is probably andesite. Malachite was observed on the claim, but assay results showed only a trace of silver and 0.02 percent copper.

Refuge No. 7. This property adjoins Refuge No. 4 on the south and is in the NW $\frac{1}{4}$  sec. 25, T. 4 S., R. 20 E. The property was opened by two shallow open cuts and a 20-foot adit now caved in andesite. Malachite, pyrite, and chalcopryite were observed, and a sample assayed a trace of silver and 2.25 percent copper.

### **Victoria Claim**

This claim is in the SE $\frac{1}{4}$  sec. 26, T. 4 S., R. 20 E., one-half mile south of the Refuge claims

(Figure 5). Bureau of Land Management geologists visited the claim and describe it as a shallow cut in a latite or rhyolite dike. Malachite and iron oxides were observed in the cut, and a sample assay ran 0.1 ounce of gold, 0.20 ounce of silver, and 2.25 percent copper per ton.

### **Copper King or Wylomine Claims**

This property consists of two claims in sec. 9, T. 3 S., R. 17 E. (Figure 6). According to Bromfield and Shride (1956, p. 632), mine workings include a pit, two adits, and two shallow shafts, where Precambrian Apache Group rocks and the Troy Quartzite are intruded by diabase. Mineralization occurred in fissures in the diabase. Minerals reported are copper minerals (azurite, malachite, and chalcocite) and an iron mineral (hematite). An assayed sample of a pile of sorted ore, taken by Bromfield and Shride at the time of their visit, showed 0.02 ounce of gold, 0.9 ounce of silver, and 8.62 percent copper per ton.

### **Peacock Claims**

The Peacock Claims are in sec. 30, T. 1 S., R. 18 E. (Figure 4). Bromfield and Shride (1956) indicate that development includes several pits, cuts, and shallow inclines, and a 35-foot vertical shaft. The major workings apparently were driven into a shear zone in granite. Minerals identified by Bromfield and Shride included quartz, calcite, barite, rhodochrosite, and pyrite. The investigators note that the mineralization was part of "some weak disseminated copper mineralization" and that

the affected area appears meager and of limited areal extent.

### **Bitter Spring Prospect**

Bromfield and Shride (1956) also visited the Bitter Spring Prospect during the course of their investigation. They describe the prospect as being in sec. 17, T. 4 S., R. 20 E. (Figure 5). Country rock is mostly andesite and rhyolite, but the workings are in two small outcrops of limestone. Malachite, pyrite, and magnetite were noted at the property, and a sample ran 0.01 ounce of gold and 1.0 ounce of silver per ton. Evidently, no assay for copper was made.

### **Geronimo Prospect**

The Geronimo prospect of Bromfield and Shride (1956) is in sec. 11, T. 4 S., R. 21 E. (Figure 6). Workings include a 100-foot shaft and two shallow cuts in diorite that has intruded granite. Both iron oxides and sulfides can be found at the surface. Bromfield and Shride believe that this indicates that erosion has kept pace with oxidation and no secondary enrichment should be found at depth.

### **Tribal Claims**

These claims are in sec. 33, T. 2 S., R. 22 E. (Figure 6). Development is in a fault with one wall in Cambrian quartzite and the other in Devonian or Carboniferous limestone. The workings consist of a caved adit and three shallow cuts. Minerals observed by Bromfield and Shride (1956) included

quartz, hematite, malachite, and pyrite. A sample of sorted vein matter assayed 0.01 ounce of gold, 0.4 ounce of silver, and 2.27 percent copper per ton.

### **Copper Prospect**

Bromfield and Shride (1956) describe this prospect as being 4 miles north of San Carlos and ¼ mile east of the San Carlos-Sawmill road. Owing to the indefinite location of this prospect, it is not shown on [Figure 6](#). According to Bromfield and Shride, the workings consist of three pits in limestone along one side of a fault. The only mineral mentioned is malachite, and Bromfield and Shride believe the mineralization resulted from the precipitation from copper-rich ground water, which would mean that the deposit is not of economic value.

### **Prospect Near Bucket Mountain**

This prospect, in sec. 36, T. 1 S., R. 17 E., consists of several pits in a quartz vein in Precambrian granite ([Figure 6](#)). Bromfield and Shride (1956) state that pyrite is rarely seen. Quartz and feldspar are the only other minerals listed.

### **Reserves**

Reserves of this group of claims are unknown. However, both the BLM geologist and a private consultant, in court testimony during invalidation proceedings, agreed mineralization on these claims had been sufficient to warrant further exploration.

### **Gold Placers**

There is no record of gold production from placer deposits on the San Carlos Indian Reservation. Two known areas of placer gold occur just outside the reservation, however, and it is possible that some placer gold is present in the gravels of some streams within the reservation. The known placers are in the Gila River just east of the reservation and in Sixshooter Creek about 4 miles west of the reservation. Other possible placer gold occurrences are Deer and Ash Creeks in the Saddle Mountain mining district.

### **Gila River Placers**

Placer gold is known to occur in gravels deposited by the Gila River above the mouth of Bonita Creek. Bonita Creek drains the southeast corner of the reservation. Wilson (1937) reports that the gold is in terrace deposits on bluffs carved by the river. He describes the gold as being "flakey to wiry in form and ranging in size from flour up to particles ¼ inch long." Although the distance from these deposits to the reservation boundary is only about 6 or 8 air miles, the river bends and travels about 30 miles before entering the reservation. It is possible that the Gila River gravels on the reservation contain gold.

### **Sixshooter Creek Placer**

The Sixshooter Creek placer deposit is about 4 miles west of the reservation boundary and about 6 miles southeast of Globe. Wilson (1937) describes the area as the Gap and Catsclaw Flat. Only

small production apparently was realized because water had to be hauled to the area. That part of the reservation nearest Sixshooter Creek may never have been open for mineral entry. It is possible that gravels in several streams on the reservation, draining generally the same area, carry gold.

### **Saddle Mountain Mining District**

The Saddle Mountain mining district, described previously, contained gold. Ross (1925) does not mention placer deposits in the area, but it is possible that gravels in Deer and Ash Creeks, the two streams that drain the part of the district on the reservation, contain gold.

### **Ferrous Metals and Ferroalloys**

The only ferrous metal on the reservation is iron, and manganese is the only ferroalloy. Neither metal has been produced commercially, but there may be some potential for iron production. Manganese evidently has little potential for production under current conditions.

### **Iron**

Iron resources occur on San Carlos land in several deposits. Iron deposits were investigated by Bromfield and Shride (1956) and by Harrer (1964). Most deposits are small, and some of the occurrences described by these authors are in deposits mined for other minerals.

### **Great View Magnetite**

This property originally was claimed and developed as an asbestos property. According to Harrer (1964), the deposits are in NE¼ sec. 35, T. 5 N., R. 17 E. (Figure 6). He describes the occurrences as magnetite in contact-metamorphic deposits and as pyrometasomatic replacements associated with diabase intrusions. Harrer indicates that the deposits are small but suggests that exploration seems justified.

### **Iron Group Hematite**

This iron deposit, called Iron Group Hematite by Harrer (1964) and Iron Claims by Bromfield and Shride (1956), is in a fault between Paleozoic and Tertiary limestone-siltstone formations. The property is in sec. 16, T. 1 S., R. 18 E. (Figure 6). The mineralization apparently extends for about 40 feet along the fault. The deposit was explored by a 100-foot shaft, two short adits, and several cuts and pits, according to Bromfield and Shride (1956). Harrer (1964) reports that the iron is hematite and ranges in grade from less than 30 percent to 60 percent.

### **Seneca Iron Prospect**

Harrer (1964) and Bromfield and Shride (1956) all visited this property, which is in sec. 19, T. 4½ N., R. 18 E. (Figure 6). Both investigations indicate that the deposit consists of small lenses of magnetite replacing limestone near contacts where diabase has intruded the Precambrian Mescal Limestone. Harrer states that there are no prospect

pits or exploration developments at the property. A sample taken by Harrer of the deposit indicated a 50 percent iron content in sorted material.

### **Bitter Spring Magnetite**

This deposit was visited and described by Bromfield and Shride (1956) and is included with base metals above (Figure 5). Harrer (1964) also visited the property but adds little to Bromfield and Shride's description.

### **Captain Jack Magnetite-Hematite**

This property was visited and sampled by Harrer (1964). It is in sec. 26, T. 4 S., R. 19 E. in the Stanley mining district (Figure 5). According to Harrer (p. 59), magnetite and hematite (specularite) occur in several bodies in limestone near a diabase intrusion. Harrer states that there has been no production from the deposit, which is 10 to 30 feet thick and about 200 feet long. Exploration work consists of two shallow shafts, a 50-foot adit, and numerous small cuts and pits. Analyses of two samples taken by Harrer yielded 65.4 percent iron and 57.81 percent iron.

### **Brewer Magnetite**

A magnetite deposit associated with rhyolite in sec. 24, T. 4 S., R. 20 E., and one associated with diabase in sec. 21, T. 4 S., R. 21 E. (Figure 6), are described by Harrer (1964). The same author also describes a deposit of magnetite-hemstite (specularite) associated with diorite in sec. 20, T. 4 S., R. 21 E. The first deposit is about 100 feet in

diameter and has an iron content of 64.8 percent. The size of the second deposit is not given, but the iron content of a sample from the deposit showed about 44.2 percent iron. Harrer states that a third deposit is about 100 feet long, and analysis of a sample showed a 20.9 percent iron content.

### **Reserves**

Iron reserves in known deposits on the San Carlos Reservation are unknown, but all of the deposits appear to be relatively small. Bromfield and Shride (1956) state that they appear to be too small to be of significance as commercial sources of iron. Harrer suggests, however, that at least one deposit, the Great View Magnetite, should be explored.

Iron deposits other than those described may be on the reservation. Also, many of the known iron deposits in the region are associated with diabase intrusions. The Precambrian Mescal Limestone underlies large areas of the reservation and is known to be intruded by diabase at many places. Therefore, it appears reasonable to believe a systematic investigation of diabase intrusions might reveal other, and perhaps larger, iron deposits.

### **Manganese**

Manganese occurs on San Carlos land in three known deposits. Apparently, only trial shipments of ore have been made and, in aggregate, the shipments probably amounted to less than 50 tons.

## Black Rock (Davis) Deposit

The Black Rock deposit originally was a group of six claims in sec. 18, T. 4 S., R. 19 E. (Figure 5). The claims evidently were invalidated by the Bureau of Land Management when the area was given to the Tribe. The deposit is described by Farnham, Stewart, and DeLong (1961) as iron and manganese oxides "in irregular replacement bodies in beds of Paleozoic limestone." The deposit is 4 to 8 feet thick and about 250 feet long. It is opened by an inclined shaft 140 feet deep, a 60 foot open cut, and another open cut described as shallow.

The deposit was sampled by a Bureau of Mines engineer in 1941. Results of the assay showed 9.2 percent manganese and 23 percent iron. Tests on the material showed that the iron and manganese could not be separated even with fine grinding. Further tests, however, showed that a product containing 39.5 percent iron and 17.4 percent manganese could be made. It was concluded that such a product might be of value as a spiegeleisen ore. A spiegeleisen ore is a material used as a deoxidizing agent in steel making as well as to raise the manganese content of the steel. Very little spiegeleisen-type ore currently is used in the U.S. It is possible, however, that as high-grade manganese ore becomes depleted this type of ore will again be accepted.

## Other Deposits

Two other manganese deposits are known on the reservation. Farnham and others (1961) give the location as approximately secs. 32 and 33, T. 1 S., R. 20 E. The deposits are about 1 mile apart in

Salt Creek and one of its tributaries (Figure 6).

Both deposits are described by Farnham and others (1960) as manganese "in seams, stringers and irregular bunches distributed sporadically along fracture and brecciated zones in volcanic rocks." The same authors further state:

"The ore minerals are chiefly psilomelane, pyrolusite, and wad. Calcite and iron oxide are the principal gangue minerals. The larger mineralized bunches, seldom exceeding 1 foot in greatest dimension, are composed largely of small nodules and stringers of ore mixed with calcite and brecciated fragments of the wall rocks.

"Samples assaying 30 percent or more manganese, taken from the deposits, have contained 0.3 to 0.5 percent copper."

Exploration in the northern deposit consists of a few open cuts and in the western deposit a dozen or more shallow pits and cuts. At least one shipment of 20 tons of hand-sorted ore was shipped from these properties.

The copper content of this ore probably would make the material difficult to market. A copper content greater than 0.25 percent is usually not acceptable for manganese ore. Therefore, the manganese from these deposits would require blending with ores that are free or nearly free of copper to make them marketable under current specifications.

## Reserves

The quantity of manganese present on the reservation is not known, but it probably is not large. Nevertheless, there may be enough to sustain a small mining effort provided a market could be developed for the types of ores available. Overall, it appears unlikely that such a market will develop within the foreseeable future owing to the low tenor of the ore in the Black Rock deposit and the relatively high copper content of ores from the other two deposits.

## Relationship of the San Carlos Reservation to Large Mining Districts

The most cursory study of mineral resources on the San Carlos Indian Reservation reveals an interesting relationship between the location of the reservation and known mining districts in the region, some of them very large. As [Figure 7](#) shows, the reservation is surrounded on three sides by major mineral deposits that, in some cases, have yielded large quantities of minerals, particularly metals, for 80 to 100 years. New deposits still are being found, as evidenced by the fairly recent discoveries by Kennecott and Phelps Dodge near Safford close to the southeastern corner of the reservation. This development should be closely followed in the future since findings east of the reservation may have a bearing on the possibility of discovering a porphyry type copper deposit under the volcanic cover in the southeastern portion of the reservation. None have been found there yet.

Because of the geographic relationship between the mining districts and the reservation, it appears reasonable to believe that a systematic and detailed investigation of reservation land, including drilling, might reveal one or more economic mineral deposits. Of particular interest is that land lying south of a line extending from Globe on the west to about township 2 S. on the east. The division is shown as line A-B on [Figure 7](#).

Such an investigation, provided it was thorough and included exploration at depth, could accomplish one of two objectives.

1. It might discover an economic mineral resource that would greatly benefit the Tribe, and
2. If no deposits were discovered, the Tribe would be able to proceed with whatever alternative use it may have for the land without a lingering concern that the potentially best use of such land was being ignored.

## Nonmetallic Mineral Resources

Nonmetallic mineral resources known to be present on the reservation include asbestos, barite, fluorite, diatomaceous earth, gypsum, tuff (tufa stone), olivine, garnet, guano, and sand and gravel. Peridot, a variety of olivine, is produced by tribal members for use as a gemstone. Sand and gravel is produced from deposits on the reservation by two private companies and the Arizona Highway Department. Garnet is collected illegally by rock-hounds, and agate also has been collected in minor quantities in the past. Gypsum occurs inside the reservation; all production, however, is by non-Indian interests on private land just outside the reservation boundary.

## Asbestos

In terms of value, asbestos production probably far exceeds that of any other mineral produced from reservation land. Neither total production nor value of the asbestos produced is available, however.

According to Bromfield and Shride (1956, p. 641-650), all significant asbestos deposits on the reservation occur in the lower member of the Precambrian Mescal Limestone. Also, all deposits occur near (usually within 25 feet) thick sills and narrow dikes of diabase that have intruded the limestone. Other, younger limestones on the reservation do not contain asbestos because they were formed after the diabase had been intruded into the Mescal Limestone.

Bromfield and Shride (1956) suggest that because the Mescal Limestone crops out over only a small part of the western one-third of the reservation, asbestos will be found in only five areas: (1) "the extreme northwestern part of the reservation--roughly that part visible from the portion of U.S. Highway 60 that traverses the Salt River Canyon," (2) "the area of Mescal Limestone outcrop that extends northwest from Blue River to the western boundary of the reservation along the southwestern escarpment of the Natanes Plateau," (3) "the small area of outcrops of the Mescal, located 1 to 2½ miles south and southwest of Cassadore Spring along Oak Creek and its tributaries," (4) "a ridge southeast of Chromo Butte," and (5) "the Hayes-Mescal Mountains area."

Asbestos occurring on the reservation is all of the chrysotile type. It occurs as both soft and harsh fibers and all gradations in between. The soft fiber

is the most valuable because of its flexibility and high tensile strength. Harsh fiber has very limited markets. Asbestos from deposits on the reservation also has a low magnetic iron content, a property that makes it particularly desirable for use as electrical insulation. Because of high production costs and difficulty in marketing, however, Bromfield and Shride (1956) state that asbestos from the reservation or other parts of Arizona cannot easily compete with asbestos from other sources for construction industry uses.

## Apache Mine

The Apache Mine is located, according to Stewart (1955), in secs. 19 and 30, T. 1 N., R. 17 E. (Figure 8). The property apparently consists of three mines, Nos. 1, 2, and 4, and what may be as many as 11 contiguous claims. Total production from this property is unknown. The U.S. Geological Survey did receive production figures for 1957 and 1958, however. Production from the property during those two years was 596.15 tons valued at about \$291,000. The Tribe received a royalty of about \$33,500.

Apache Mine No. 1 was first developed in 1923 and was extended in 1951 by Metate Asbestos Corp. Stewart (1955) states that soft, semisoft, and harsh fibers were found, and that the harsh fibers were sold for the manufacture of acoustical and insulating block, but that the better grade material could be used as spinning-grade material.

Most production from the Apache Mine No. 2 probably came from one adit and a stope. Mineralization was "2 to 3 inches of harsh fiber in numerous veinlets in a zone about 10 inches thick"

(Stewart, 1955). Stewart also describes a 20-foot inclined adit northwest of the main workings that prospected two serpentine zones about 18 inches apart that contained 1½ to 2 inches of harsh fiber.

Production from Apache No. 2 is unknown, but part of the total production cited may have come from the Apache No. 4 Mine. Stewart (1955) describes the No. 4 mine as a 65-foot adit that follows an upper 8- to 12-inch serpentine zone that contains 2 to 3 inches of harsh fibers, and a discontinuous serpentine zone about 1 foot below that contains veinlets of short, harsh fiber. A bulldozer cut and a 10-foot adit explore two serpentine zones that contain several narrow fiber veinlets. Whether mineral was shipped from these workings is unknown.

### **Mystery Group**

This property, in secs. 9 and 16, T. 2 S., R. 17 E., consists of two deposits about 150 feet apart in elevation (Figure 8). The upper deposit contains two serpentine zones about 1 to 2 feet apart that contain about 1 inch of fiber. The lower deposits show one serpentine zone containing 2 to 4 inches of soft fiber (Stewart, 1955). Bromfield and Shride (1956) state that all fiber in the upper deposit is semiharsh and of poor strength and that the lower deposit pinches out about 20 feet behind the outcrop.

### **Chiricahua Group**

Stewart (1955) gives the location of this unsurveyed property as secs. 9 and 16, T. 2 S., R. 17 E. (Figure 8). The showing, according to both

Stewart (1955) and Bromfield and Shride (1956), consists of four serpentine zones all of which contain asbestos. Workings are limited to one shallow prospect pit. Bromfield and Shride (1956) indicate that the asbestos in the upper zone is 1½ inches long and is soft with good tensile strength, but the material in the lower three zones is harsh and of moderate or poor tensile strength.

### **Dream Girl Prospect**

This prospect, in sec. 27, T. 5 N., R. 17 E., yielded a small amount of asbestos during 1942-1943, according to Stewart (1956). Stewart places the prospect on the reservation, but sec. 27, T. 5 N., R. 17 E. is about 1 to 2 miles west of the reservation. This prospect is not shown on Figure 8. Mine workings include three adits 25, 45, and 90 feet long. Stewart (1956) states that a slope in the 90-foot adit reached the surface. Two serpentine zones are present in the deposit. The upper zone contained ¾ inch of fiber, and the lower zone contained 1½ to 2 inches of fiber. Stewart (1956) indicates that fiber from this property is soft and of good tensile strength. He also states that all the minable asbestos has been removed.

### **Cassadore Deposit**

The Cassadore deposit is in sec. 30, T. 2 N., R. 19 E. (Figure 8). Development consists of a series of open cuts in several serpentine zones. Stewart (1956) indicates that the asbestos in the deposit is semisoft to harsh. It is not known whether asbestos was produced.

## Bear Canyon Mine

The Bear Canyon properties are made up of 19 unsurveyed claims in secs. 2 and 11, T. 2 N., R. 19 E., according to Stewart (1955). This mine, according to both Stewart (1955) and Bromfield and Shride (1956), is one of the largest in Arizona. Bromfield and Shride (1955) state that about 1,200 tons of all grades of asbestos were produced from the property between 1921 and 1954. The same authors also state that "little further production can be expected from the Bear Canyon Deposit."

The mine workings are fairly extensive, but, according to Stewart (1955), most of the production came from one large slope.

The mine was developed on three levels, with the upper level 40 feet above and the lower level 80 feet below the outcrop entries.

## Prospects Along Upper Bear Creek

According to Bromfield and Shride (1956), a series of four prospects occurs in an area north of the Bear Canyon Mine (Figure 8).

Prospect No. 1 is about one-half mile north of the Bear Canyon Mine. Bromfield and Shride (1956) state that the deposit contains 1½ inches of semiharsh fiber that is confined to within 15 to 20 feet of the diabase-limestone contact. Development consists of one 75-foot adit. Apparently, no asbestos was produced.

Prospect No. 2, as described by Bromfield and Shride (1955), is one-half mile northeast of prospect No. 1. Development is limited to one 15-foot adit that explores an 8- to 10-inch serpentine band containing 2 to 3½ inches of harsh fiber. The same

authors also describe a serpentine zone containing 1½ to 2 inches of harsh fiber about 5 feet above the zone on which the adit was driven. Evidently, no asbestos was produced.

Prospect No. 3, according to Bromfield and Shride (1956), is a "few tenths of a mile" south of prospect No. 2. Development consists of an adit with two branches, one 25 feet long and the other 45 feet long. The adit explores a serpentine band that ranges between 6 inches and 15 inches thick and contains 1½ to 3 inches of semiharsh fiber. Another serpentine zone about 5 feet above the adit is described as containing 2 inches of semiharsh fiber. A prospect pit about 80 feet west of the adit disclosed a serpentine zone containing 1 to 2 inches of semiharsh fiber (Bromfield and Shride, 1956). No production has been reported.

Prospect No. 4 is on the east fork of Bear Creek about 1 mile north of its junction with the west fork. Development is limited to one 40 foot adit that explores two serpentine zones about 3 feet apart. The upper zone is 4 to 6 inches thick and contains up to one-half inch of semiharsh fiber. The lower zone is 3 inches thick and contains about 1 inch of semiharsh fiber. There has been no production (Bromfield and Shride, 1956).

## Sorsen-William (Salt River) Claim

This property consists of four adjoining unsurveyed claims in secs. 25 and 26, T. 5 N., R. 17 E. (Figure 8). According to Stewart (1955), the deposit is developed by three adits. Stewart reports that "good fiber" was encountered in No. 1 adit, but that the mine required so much support that it was uneconomical to mine. The other two adits

encountered asbestos that was either harsh or otherwise noncommercial. Bromfield and Shride (1956) note that "some asbestos" was mined during 1953 but do not state the exact quantity. The same authors state that the south deposit would be difficult to mine because of fractures in the rock, although it may contain asbestos. Bromfield and Shride also note that any asbestos found in the south deposit might be badly weathered owing to rock fractures.

### **Emsco Mine (Accident Claims)**

The unsurveyed Emsco Mine is probably in sec. 13, T. 4½ N., R. 18 E. (Stewart, 1955) (Figure 8). The property was mined intermittently between 1921 and 1952. Bromfield and Shride (1956) state that 210 tons of Nos. 1, 2, and 3 fiber have been produced from the mine as well as 2,700 tons of mill rock. The quantity of asbestos in the mill rock is unknown.

Development consists of several hundred feet of drift and slopes. The workings are in two serpentine zones about 15 feet apart. The upper or more productive zone is 10 to 20 inches thick and contains 1 to 4 inches of short soft fibers in numerous veinlets. The lower zone is 6 to 12 inches thick and contains 3 to 4 inches of soft fiber. The potential for further development of the property is unknown.

### **Pine Top Group**

According to Stewart (1955), the Pine Top Group of 10 unsurveyed claims is probably in sec. 14, T. 5 N., R. 17 E. This location is about 1 mile

north of the northwest corner of the reservation; however, Stewart lists it as being on San Carlos land. It is not shown on Figure 8. Bromfield and Shride (1956) state that 125 tons of harsh fiber and 2 to 3 tons of soft fiber were produced from these deposits prior to 1943 and possibly a few hundred tons of harsh fiber were produced between 1945 and 1956. Stewart (1955) indicates that several carloads of long harsh fiber were produced prior to 1951 and substantial tonnage was produced during 1951-1952.

The property has been developed by at least 17 adits and some stopes. The asbestos was produced from several zones and is from about ½ inch to 5 inches long. Bromfield and Shride (1956) note that "Unless a special market can be developed for this asbestos, the harsh fiber deposit of the Pine Top Claims will probably continue to be difficult to exploit commercially." From this conclusion, it is assumed that the mine has reserves, but neither Bromfield and Shride nor Stewart make an attempt to quantify the material remaining in the deposits.

### **Great View Mine**

This property is in sec. 35, T. 5 N., R. 17 E. The quantity of asbestos produced is unknown. Section 35 is adjacent to, but outside, the west boundary of the reservation. Stewart lists it as being on the reservation. It is not shown on Figure 8. Stewart (1955) indicates that a small amount of fiber was produced in 1921 and 1953. Asbestos also may have been produced at other times, but no record exists of such production. Stewart states that the 80-foot adit and two 35-foot side drifts are

wide, indicating that a considerable amount of asbestos was mined.

Workings on the property consist of the 80-foot adit and two 35-foot drifts. Stewart (1955) notes that a zone above the adit has been explored by several cuts and adits.

The asbestos mined in the main workings was in a 14-inch serpentine zone that contained 1½ to 3 inches of "fairly harsh" fiber. The other workings, according to Bromfield and Shride (1956), are in two serpentine zones that contain semiharsh fiber 1 to 2 inches long. Those authors state that at least two other serpentine zones exist but have not been prospected. The quantity of asbestos on the property, if any, is not known.

#### **Golden Fiber Asbestos Claims 1 and 2 (Old Falls Group)**

This unsurveyed property is adjacent to and northwest of the Pine Top Claims and is probably in sec. 35, T. 5 N., R. 17 E. Owing to lack of a precise location, it is not shown on [Figure 8](#). The major production from the property apparently was obtained before records were kept because Stewart (1955) states that there are two fairly large dumps and caved adits on the property. Other workings consist of a 15-foot adit and a small stope that developed a 2-foot serpentine band containing 2 inches of soft fiber. Stewart also notes that another 50-foot adit explored two serpentine zones 6 feet apart that contained as much as one half inch of soft fiber. Reserves on the property, if any, are not known.

#### **Sulphur Springs Claims**

The Sulphur Springs Claims are in sec. 29, T. 4½ N., R. 18 E. ([Figure 8](#)). According to Bromfield and Shride (1956), development consists of a 10-foot adit and an open cut. The workings explored a 24 to 30-inch serpentine zone containing ⅛ to 2 inches of soft fiber. Reserves, if present, are not known.

#### **Black Mesa Deposit**

This prospect is in sec. 30, T. 2 N., R. 19 E. ([Figure 8](#)). The asbestos occurs in two zones. The upper zone, according to Bromfield and Shride (1956), is of little importance. The lower zone is explored by four pits along a 9- to 15-inch serpentine zone that contains 1½ to 2 inches of fiber. Neither the quality of the fiber nor the possible reserves are given.

#### **Prospect North of Red Whiskers Spring**

This prospect is in sec. 20, T. 2 S., R. 17 E. ([Figure 8](#)). According to Bromfield and Shride (1956), asbestos is present intermittently in two serpentine zones about 7 inches apart.

The asbestos is reported to be semiharsh and ¼ to ½ inch in length. Reserves are unknown.

#### **Asbestos Occurrence on Oak Creek**

Bromfield and Shride (1955) mention that "rather short fiber is present in a serpentine zone in sec. 24, T. 1 N., R. 18 E." ([Figure 8](#)).

## Prospect West of Blue River

An occurrence of asbestos has been prospected in sec. 17, T. 2 N., R. 20 E. ([Figure 8](#)). Bromfield and Shride (1956) report an open cut and a short adit in an 18-inch serpentine band containing  $\frac{1}{2}$  to  $\frac{3}{4}$  inch of asbestos. The fiber is described as harsh to semiharsh. The authors also describe a pit about 300 feet northeast of this location as showing  $\frac{1}{10}$  inch of fiber.

## Unnamed Asbestos Prospect

Bromfield and Shride (1956) describe  $\frac{1}{2}$  to  $\frac{3}{4}$  inch of harsh to semiharsh fiber in a pit about  $\frac{2}{3}$  mile south of I.S. Hole Canyon. I.S. Hole Canyon joins the Salt River about 2 miles east of Highway 60 over the Salt River in Salt River Canyon. Because the location of the prospect is indefinite, it does not appear on [Figure 8](#).

## Reserves

Little is known of asbestos reserves on the San Carlos Indian Reservation. Bromfield and Shride (1956) and Stewart (1955 and 1956) all indicate that most asbestos deposits in the area are small. Many of the deposits cited herein may have been exhausted. Some of the known deposits may have minable reserves, however, and it is likely that some deposits remain to be discovered. Lengthy and detailed fieldwork would be required either to prove additional reserves in known deposits or to locate new deposits.

## Barite

Barite occurrences have been known on what is now the San Carlos Reservation since before 1925. Three barite deposits have been identified in addition to the barite present as a gangue mineral in ores from the Starlight Mine and a few other mines and deposits. The Starlight and other properties are described in a previous section of this report. One barite deposit was worked to a limited extent for the contained silver.

## Barium King Group

This property is in sec. 19, T. 4 S., R. 20 E. and sec. 24, T. 4 S., R. 19 E. ([Figure 8](#)). Ross (1925) mentions the deposit under the name Mitchell Barite Prospect, but does not describe the mineralogy or development other than to state that it had been prospected. Stewart and Pfister (1960) visited and sampled the occurrences in 1960 and state that barite occurs in three separate deposits on the property. The deposits are described as veins in trachyte.

The first deposit, according to Stewart and Pfister, is a vein at least 50 feet wide and 200 feet long. Development apparently is limited to a shallow cut and a bulldozed bench.

The second deposit has been explored by a bulldozer cut and a 10 foot shaft. Stewart and Pfister describe the mineralization as exposed "over an area of 50 by 150 feet through vertical range of some 30 feet."

The third deposit has not been prospected, according to Stewart and Pfister. However, they describe the mineralized area as measuring 20 feet

by 60 feet. Part of the deposit is covered by a rock slide; therefore, the mineralized zone may encompass a larger area than the dimension given.

Apparently, Stewart and Pfister sampled only the first and second deposits. They give assay results as 62.2 percent  $\text{BaSO}_4$  (barite) and 10.6 percent  $\text{CaF}_2$  (fluorite) for deposit No. 1, and 64.8 percent  $\text{BaSO}_4$  and 11.5 percent  $\text{CaF}_2$  for deposit No. 2.

Metallurgical tests on the samples showed a barite concentrate containing 92.5 percent  $\text{BaSO}_4$  and 96.7 percent  $\text{CaF}_2$  could be made from these ores. Products containing those quantities are commercial grade.

### **Little Mule Group**

This property originally was made up of six claims located in 1907. The property is at the top of Stanley Butte in secs. 2, 11, and 12, T. 5 S., R. 19 E. (Figure 8). The deposit consists of barite in fractures in diorite porphyry.

The deposit reportedly was worked for silver during the early part of the century. Development, as reported by Stewart and Pfister (1960), consists of an inclined shaft more than 100 feet deep, a caved adit 170 feet long, a 20-foot inclined shaft, and several open cuts. The purpose of the workings was to recover the silver in the ore; barite apparently was not recovered. This property may be the same deposit described by Ross (1925) as the Silver Spar Prospect. A description of that property is in the base and precious metals section of this report.

No metallurgical tests were run on samples from this deposit, but assays of the samples gave

74 percent  $\text{BaSO}_4$  and 14 ounces of silver to the ton (Stewart and Pfister, 1960).

### **Coronado Group (Copper Reef Deposits)**

This deposit is near the old Copper Reef Mine in secs. 28 and 29, T. 4 S., R. 19 E. (Figure 8). The Copper Reef Mine is described in the section on base and precious metals of this report. Stewart and Pfister (1960) describe this area as containing several minor barite deposits. The investigators evidently did not sample deposits at this location. They state, however, that all the barite contained small amounts of fluorite. Whether barite could be recovered from any of these deposits is unknown.

### **Other Barite Occurrences**

Stewart and Pfister (1960) state that barite occurs in deposits about one-half mile northwest of the Little Mule Group. The same authors also report barite on the south side of Stanley Butte about 1,500 feet from the highest peak. Evidently, no samples were taken on these properties.

### **Reserves**

No figures exist for the quantity of barite reserves on the San Carlos Reservation. They apparently are moderate to large, however. The veins in the Barium King Claims are as much as 50 feet wide and 150 feet long. The veins in Little Mule Group are narrow, up to 18 inches wide, but they reportedly contain a significant silver content (14 oz); at least one vein in the Coronado Group is as much as 5 feet wide. Whether the deposits

actually are large enough to sustain a mining operation cannot be determined without a field examination.

### **Diatomaceous Earth**

Diatomaceous earth occurs on the reservation in at least two areas. The first is in sec. 26, T. 1 N., R. 18 E., and the second in secs. 1 and 11, T. 2 S., R. 19 E. (Figure 8). Bromfield and Shride (1956) visited both areas and state that the diatomaceous earth is found in association with late Tertiary or Pleistocene lake beds. The lakebeds cover a large part of the San Carlos-Gila River Basin, so it is possible that other deposits of diatomaceous earth are present on Indian land.

According to Bromfield and Shride, the deposit in sec. 26, T. 1 N., R. 18 E., crops out on the west bank of a wash and can be traced for about 600 feet. A 54-foot section showed several beds of diatomaceous earth interbedded with limestone and tuff. Only one 2-foot bed is described by the authors as being of good quality. The other beds are reported to contain clay and thin limestone beds.

At the second location, secs. 1 and 11, T. 2 S., R. 19 E., a 197 foot section was measured. The length of the outcrop, according to Bromfield and Shride, is about 1,000 feet. The diatomaceous earth beds are interbedded with marl and limestone.

The same authors state that the diatomaceous beds contain too much lime and clay to be of commercial importance as a filtration material. They suggest, however, that it might be suitable for making low-grade insulation brick or as a heat insulator. Because lightweight aggregate made

from diatomaceous earth has low strength, any such product made from San Carlos material would have a very limited market.

### **Gypsum**

Gypsum currently is produced from deposits off the reservation that extend into the southwest tip of Indian lands (Figure 8). According to the U.S. Geological Survey and others (1969, p. 371-381), gypsum occurring on the reservation is in the Cenozoic Gila Group. Individual massive gypsum beds, 1 to 8 feet thick, occur in a zone about 100 feet thick. The material is mined by National Gypsum, Winkelman Gypsum, and Pinal-Mammoth Gypsum. According to BIA personnel, all operations are just off the reservation in secs. 25, 26, and 35, T. 6 S., R. 16 E. Whether gypsum occurs in sufficient quantity in these deposits where they extend onto the reservation to sustain a mining operation is unknown. Whether the gypsum, even inside the reservation, belongs to the Tribe is unknown. Figure 2 shows an area of patented land in the corner of the reservation near the gypsum mines.

Gypsum also is found near the community of San Carlos in sec. 16, T. 1 S., R. 18 E. According to Bromfield and Shride (1956), these deposits never have been mined commercially. The gypsum deposits occur in Tertiary or Pleistocene lakebeds and can be traced intermittently for about 2,500 feet. The gypsum beds, which are from 3 to 5 feet thick, are interbedded with gypsiferous mudstone. Bromfield and Shride state that the base of the gypsum-bearing section is not exposed, owing to gravels which cover the surface in the area, but that

low mounds that rise above the gravels are made up of gypsite, an earthy gypsum-bearing material. Therefore, the gypsum beds may extend to some depth below the outcrops.

Bromfield and Shride indicate that perhaps 100,000 tons of gypsum is minable by surface mining methods at this location. Other material would be available by underground methods. Because gypsum is widespread in the region, however, it is doubtful that a market could be found for gypsum mined from these deposits.

### **Tuff (Tufa Stone)**

In relation to most other minerals that have been produced on the San Carlos Reservation, tuff probably is second in value only to asbestos or perhaps copper from the Starlight Mine. The stone, locally called tufa stone, occurs over a wide area near San Carlos and has been used to construct most of the government buildings in the community of San Carlos as well as several buildings in Globe. Bromfield and Shride (1956) describe the quarry from which the stone was mined as being in sec. 2, T. 1 S., R. 18 E., but the material also occurs near the surface in secs. 1, 2, and 3, T. 1 S., R. 18 E., secs. 4-9 and 16-18, T. 2 S., R. 18 E., and secs. 27-29 and 32-34, T. 1 N., R. 18 E. (Figure 8). The stone is described as attractive, white, light-weight tuff, ranging in thickness from 1 to 5 feet and averaging 3.5 feet. Overburden in the vicinity of the quarry is a few feet up to 20 feet. The dry weight of the stone is about 55 pounds per cubic foot. Crushing strength of the material is unknown, but it is apparently sufficient for building purposes

as several two story buildings have been constructed from it.

Reserves of tufa stone near the community of San Carlos are very large. No known production of the material has occurred for many years.

### **Olivine**

Olivine occurs on the reservation at two widely separated locations, (1) on Peridot Mesa near the villages of San Carlos and Peridot, and (2) on the mineral strip in T. 4 S., R. 19 E., where several veins of olivine crop out along the Starlight Mine road (Figure 8).

Gem quality olivine, called peridot, is mined on Peridot Mesa (Figure 8) by individual tribal members. The peridot occurs as individual crystals and ranges in size from microscopic to about 1 inch in diameter. It occurs in the Tertiary basalt capping Peridot Mesa. Mining consists of breaking the fractured basalt with hand tools and hand picking single crystals. Occasionally, a contractor is hired to drill and blast the basalt to fracture it so that hand tools can be used more effectively. Color ranges from light green to dark, almost black. Individual producers indicate that they can make from \$10 to \$200 per day collecting the material for sale to gem cutters and rock shops. The Tribe maintains an outlet for peridot in a shop at Cutter for those people interested in both rough and tumbled stones.

There has been no development of the olivine occurring in veins along Starlight Road. It is not known whether the vein olivine contains gem quality material.

Olivine is used for molding sand in foundries and for other purposes where its refractory properties are desirable. According to Sinkankas (1959), the olivine on Peridot Mesa makes up from 25 to 40 percent of the rock mass. According to Teague (1975), olivine deposits that are being considered for commercial application should contain in excess of 40 percent MgO (magnesium oxide) before any beneficiation. The olivine on Peridot Mesa apparently meets that specification because Sinkankas (1976) shows an MgO content of 48.34 percent. No analyses are available for the olivine on Starlight Mine road.

Most of the olivine handled by Indian collectors on Peridot Mesa is discarded along with the basalt because the individual grains are too small to be of value for gems. Also, it is possible that some areas of the mesa do not contain gem quality olivine and, therefore, would be suitable areas for producing an industrial grade product. Likewise, it is possible the olivine found along Starlight Mine road would make an industrial grade product. Such a statement cannot be verified, however, without a field examination.

Large quantities of olivine and peridot occur on the reservation. Provided the material is of sufficient quality, it is possible that it could be produced for use as a foundry sand or other uses for which its refractory properties are required.

## Garnet

For years garnet has been collected by rockhounds from occurrences on the reservation. The practice now is forbidden by the Tribe. According to Sinkankas (1959), the garnet is the andradite

variety and some of it is suitable for cutting gemstones. Sinkankas gives the locations of the garnet occurrences as Limestone Mountain, Crystal Peak, and the southern flank of Quartzite Mountain (Figure 8). Although garnet occurs in metamorphic rocks of the Stanley mining district, it is not known whether there is an association between the garnet and the mineralization of the area.

Garnet is useful as an abrasive as well as a gemstone, and it is possible that if a sufficient quantity of the material exists on the reservation it could be produced for that purpose. No information is available concerning the quantity of the material present, however, and estimates must await a field examination of the area.

## Guano

According to Bromfield and Shride (1956), several caves on the reservation contain guano. A small production was obtained from one cave in sec. 8, T. 1 N., R. 20 E. Production is reported as 63 tons valued at \$15 per ton in 1933 and 1934. The cave is described as 30 or 40 feet long and 50 feet wide. The thickness of the guano was measured at about 10 feet. Although several caves scattered over the reservation contain guano, their individual reserves are small and probably do not exceed a few hundred tons.

## Sand and Gravel

Large quantities of sand and gravel occur on the San Carlos Reservation. According to BIA records at San Carlos, only three companies currently produce the material from San Carlos land.

Also, the Arizona Highway Department has a 5-year lease for sand and gravel production on five tracts of land.

Sand and gravel are being produced by Tonto Apache Construction Corp. in T. 1 S., R. 17 E., about 1 mile south of Highway 70. The quantity of material produced or royalty paid to the Tribe is unknown. Another producer is Jim Dutton Sand and Gravel Co. The company guaranteed the Tribe 22,000 tons of production at a royalty of \$0.22 per ton. It also agreed to pay \$0.25 per ton for all production over 22,000 tons. The company will produce the sand and gravel from a pit in sec. 11, T. 1 S., R. 16 E. (Figure 8).

Corn Construction Co. has a current lease on two pits in secs. 8-10, T. 1 S., R. 23 E. (Figure 8). The lease covers 57.39 acres. Royalty to the Tribe

was \$0.29 per cubic yard of material removed. As of February 1980, the company had removed about 30,000 cubic yards of sand and gravel. The same company had earlier leases on other land for sand and gravel production, however, and it is not clear whether part of the production was from the earlier lease holdings. Table 1 shows the location of Corn Construction Co. leases on the San Carlos Indian Reservation.

Arizona State Highway Department has leases at several locations on the reservation (Figure 8 and Table 2). Royalties to the Tribe ranged from \$0.06 to \$0.15 per ton. The Tribe was paid a royalty of \$0.15 per ton for overburden removal. Leases shown in Table 2 were signed in 1979 and are for a period of 5 years.

TABLE 1  
Sand and Gravel Deposits Leased by Corn Construction Co.\*

Permit No.	Section	Township	Range
S&G-80-1	11, 12	1S	19E
S&G-80-2	8, 9, 10	1S	23E
S&G-80-3	8, 9, 10	1S	23E
S&G-80-4	11, 12	1S	19E
S&G-79-1	8, 9, 10	1S	23E

\*It is not known whether the company leased the same property more than once or whether these leases represent different pits in the same sections.

**TABLE 2**  
**Sand and Gravel Leases Held by the Arizona State Highway Department**

Section	Township	Range	Size (acres)
31	3S	22E	14.5
--	3 & 4 S	22E	43.8
11	1S	16E	50.17
32	2S	21E	25.6
--	4S	22E	9.12
16	1S	18E	18.85

Other sand and gravel pits may be located on San Carlos land, but current records do not include information concerning sand and gravel production prior to about 1978.

The quantity of sand and gravel present on the San Carlos Reservation is adequate to supply the Tribe with material both for its own use and for sale to private concerns for many years.

### MAP COVERAGE

The USGS has published 7.5- and 15-minute topographic quadrangle maps covering the entire reservation (Figure 9). The USGS also has published a "Geologic Map of Arizona," together with a "Salt River Arizona Map" on a scale of 1:31,680 that covers the Salt, Black, and White Rivers.

In addition to the topographic and geologic maps listed, the USGS has published a base map of the State of Arizona. All listed maps may be ordered from the U.S. Geological Survey, Branch of Distribution, Central Region, Box 2586, Denver, Colo. 80225.

Another useful source of maps is the Bureau of Land Management, which has available land-

status-master-title plats, accompanied by an historical index. Both the plats and historical indexes may be ordered from the U.S. Bureau of Land Management, 2400 Valley Bank Center, Phoenix, Ariz. 85073. Township and range should be designated.

The Arizona Department of Transportation publishes county road maps of the reservation. The Gila, Graham, and Pinal County maps are available. Requests should be addressed to the Arizona Department of Transportation, Engineering Records Group, 206 S. 17th Ave., Phoenix, Ariz. 85007. The Arizona Bureau of Mines publishes a series of geologic and mineral maps that may be purchased from the Arizona Bureau of Mines, 845 North Park Ave., Tucson, Ariz. 85719. The Arizona Department of Natural Resources in Phoenix also may have pertinent map information.

Aerial photographic coverage of the reservation is available from the U.S. Geological Survey NCIC-W, 345 Middlefield Road, Menlo Park, Calif. 94025. Satellite imagery can be obtained from the U.S. Geological Survey, EROS Data Center, Sioux Falls, S. Dak. 57198.

## **RECOMMENDATIONS FOR FURTHER WORK**

The general geology of the San Carlos Indian Reservation and the mineral commodities present are reasonably well known. Future investigations should concentrate on field studies aimed at outlining the most promising areas of mineral potential and at quantifying the resources available. Detailed examinations then would be required to determine more exactly the size, uniformity, depth of burial, grade, or other factors of importance in producing individual commodities under favorable market conditions.

Fieldwork should be concentrated in that area known as the "Mineral Strip," but investigations also should include work in iron, olivine, diatomaceous earth, and gypsum located on the reservation but outside the mineral strip. Moreover, in view of the large copper deposits that surround the southern half of the reservation, efforts should be made to determine whether like deposits exist within the reservation.

More specifically, field studies might include the following:

(1) Examining areas of known Laramide intrusive activity for evidence of copper-molybdenum and lead-zinc mineralization in and adjacent to stocks, of which there are a few in the southwest part of the reservation.

(2) Examining areas of known pipes and diatremes for evidence of copper mineralization.

(3) Determining the location and extent of carbonaceous siltstones of the upper Dripping Spring Quartzite for uranium mineralization.

(4) Examining the Mescal Limestone, where intruded by diabase sills, for iron deposits.

(5) Examining in detail the Paleozoic limestones, Precambrian quartzites, and consolidated gravels for favorable manganese areas, noting the presence or absence of contaminants such as copper.

(6) Examining the Mescal Limestone in favorable areas near diabase dikes and sills for asbestos.

The mineral studies are phased to occur in sequential stages, each after the first being dependent upon the findings of the previous stage. Phase I, completed with the issuance of this report, is a mineral literature study to assemble and summarize what is already known. Phase II, the next step, would be a detailed field examination to map, sample, and analyze resource prospects. Phase III, if warranted by the Phase II findings, would involve exploration to ascertain the grade and extent of the more promising mineral deposits. Such exploration may require drilling, geophysical and geochemical surveys, and other standard procedures.

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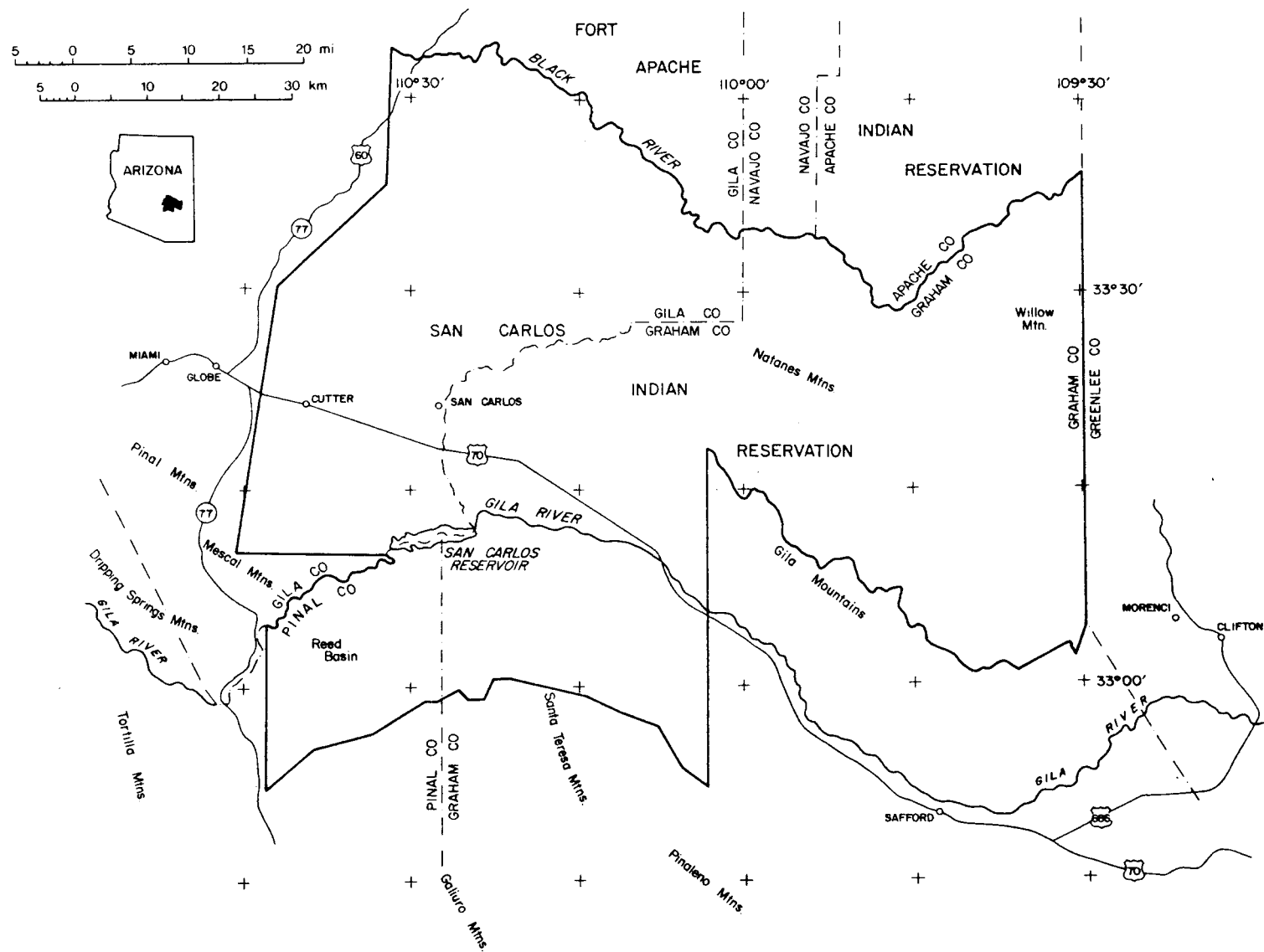
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**Figure 1.** Index map showing relationship of San Carlos Indian Reservation to surrounding features.

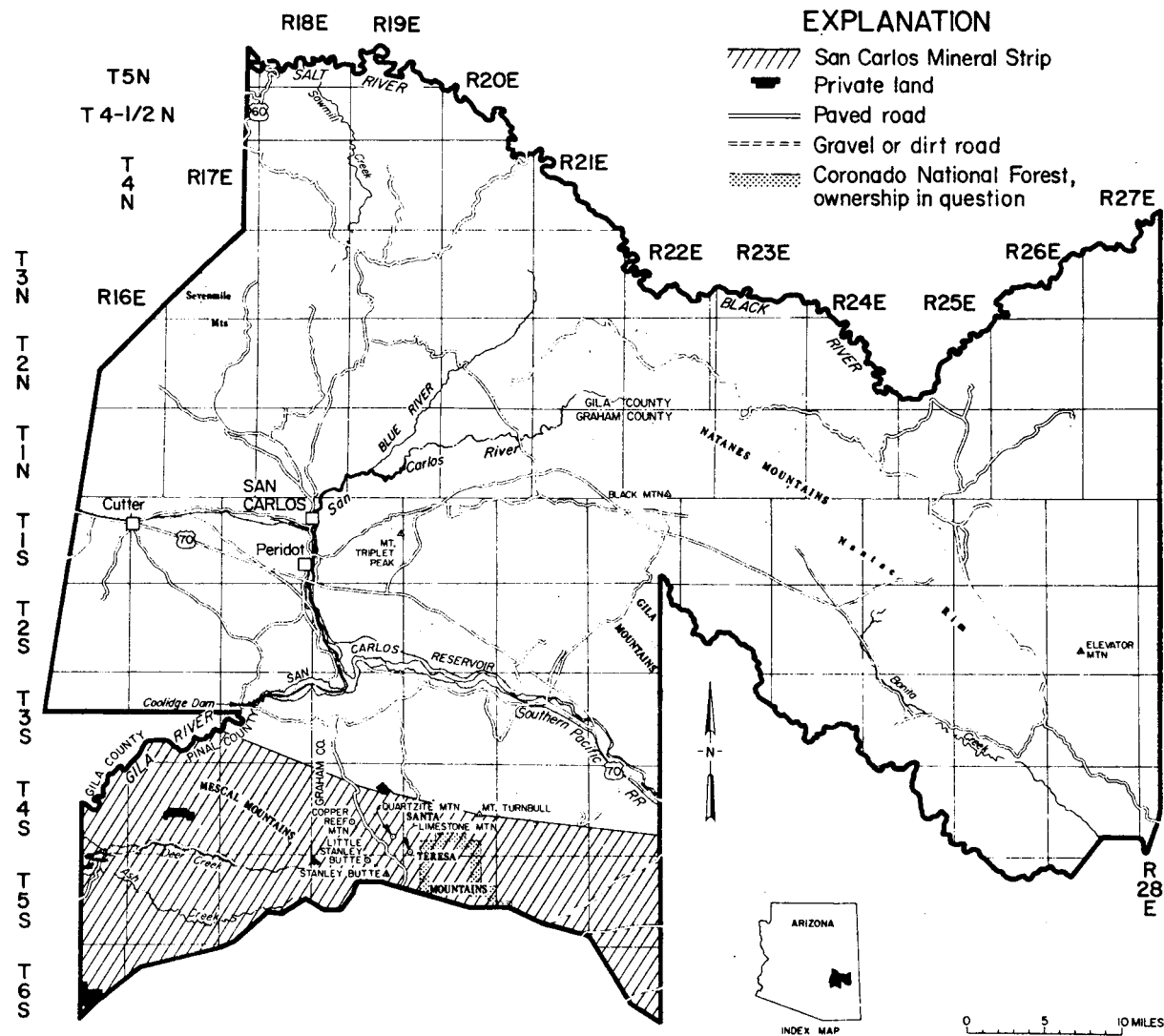
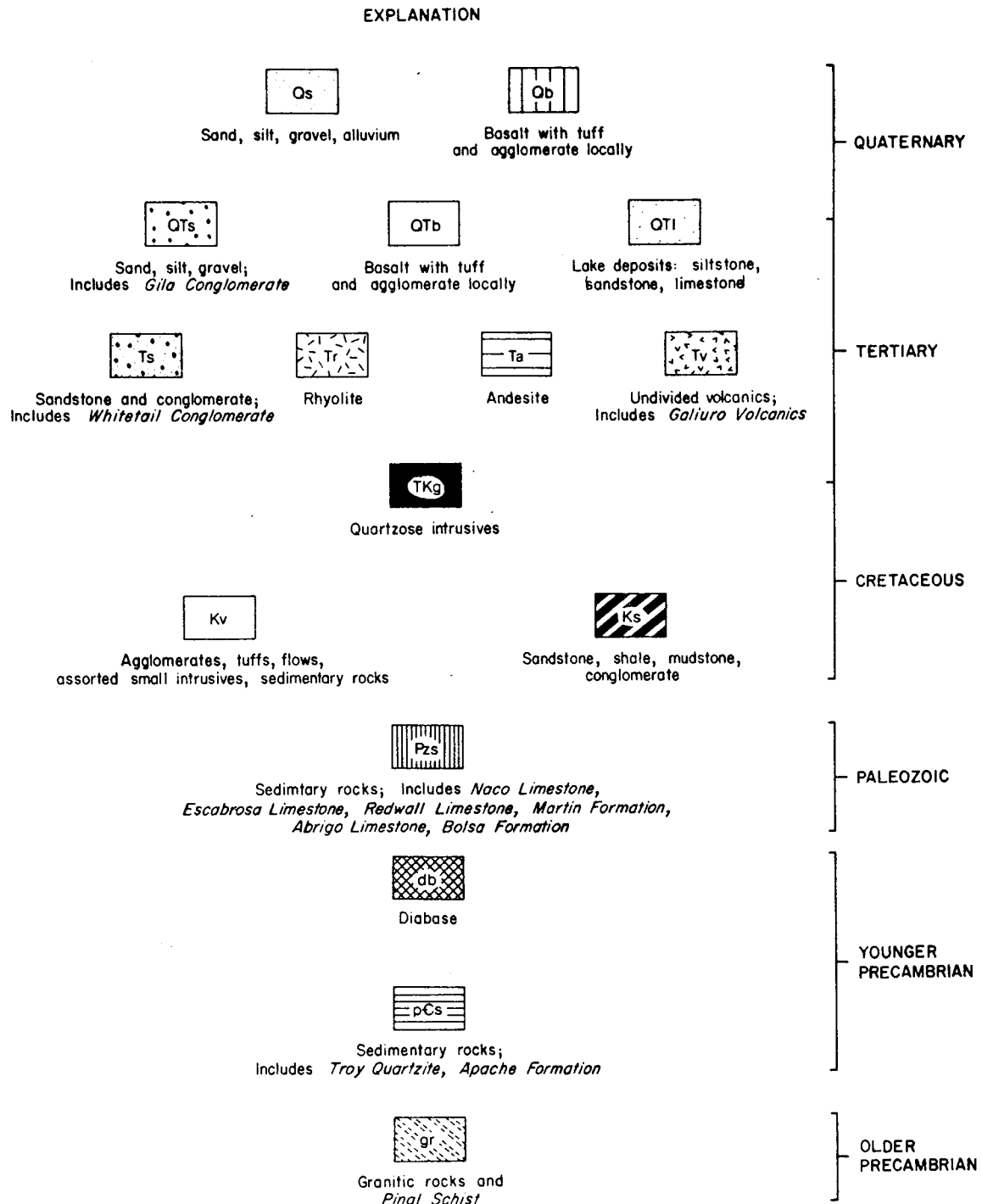
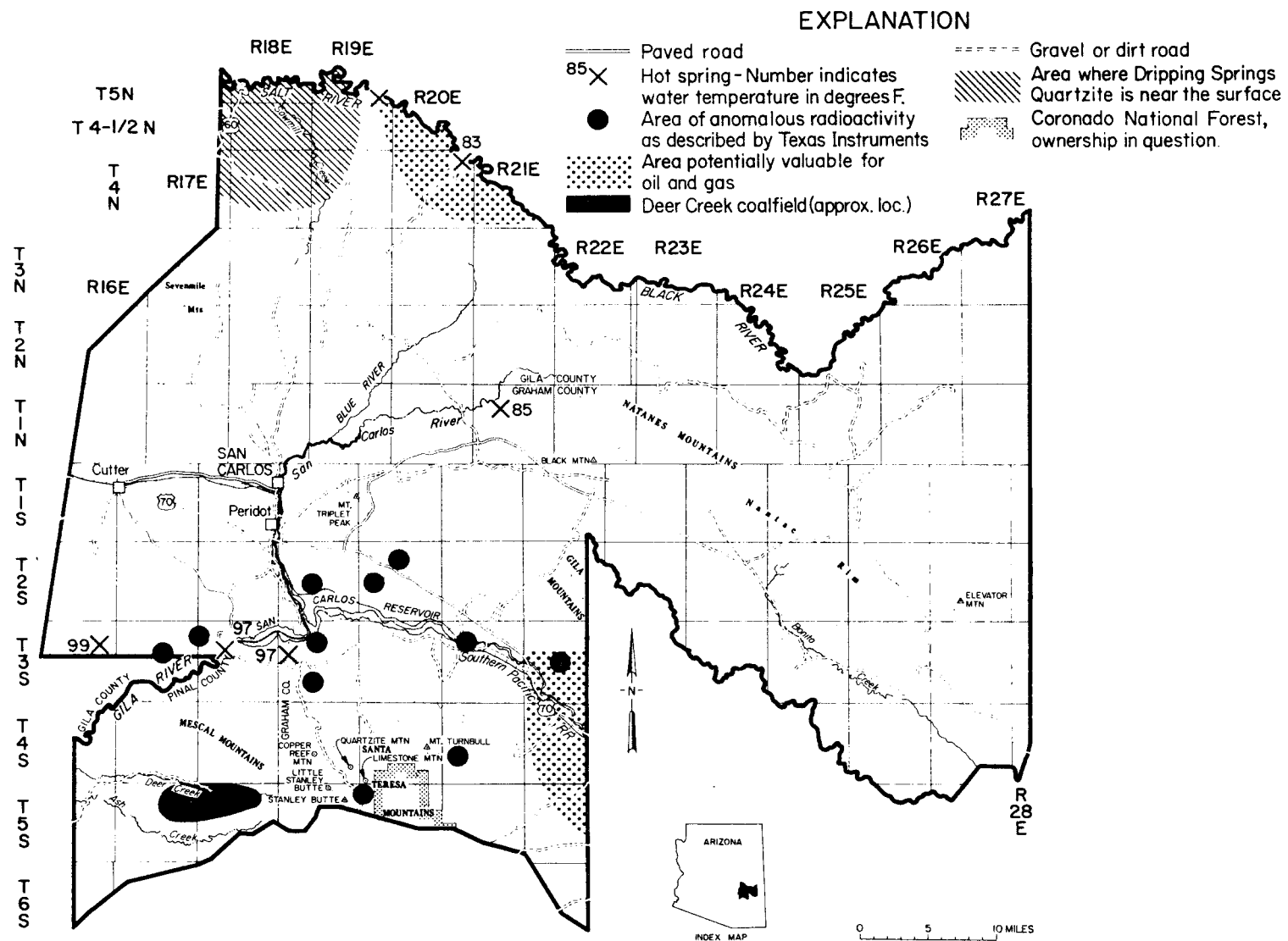


Figure 2. Map of San Carlos Indian Reservation, Arizona.

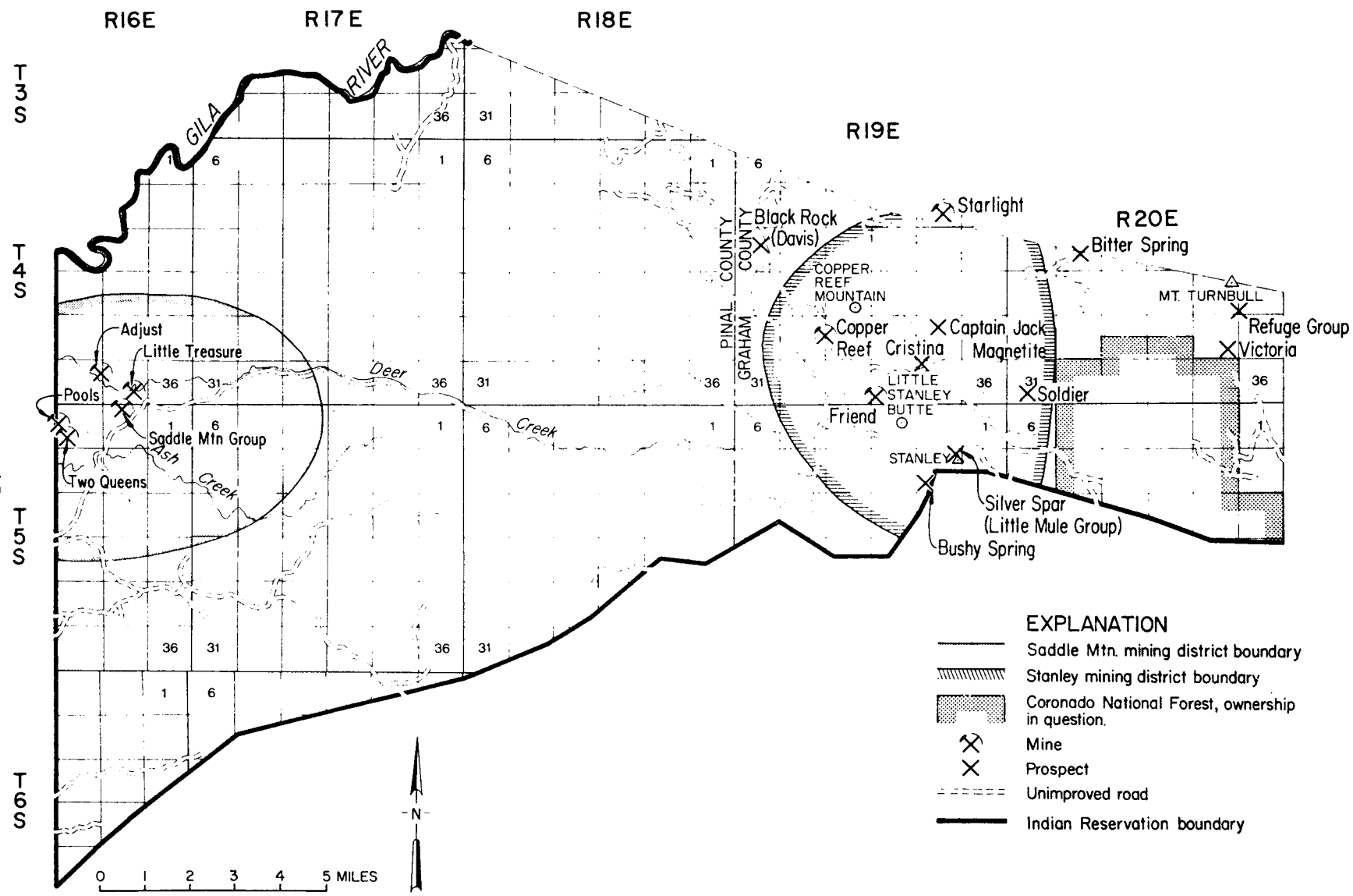




**Figure 3a.** Explanation for [Figure 3](#).



**Figure 4.** Map showing fuel resources of the San Carlos Indian Reservation, Arizona.



**Figure 5.** Map of part of the "Mineral Strip" of the San Carlos Indian Reservation, showing the Saddle Mountain and Stanley mining districts.

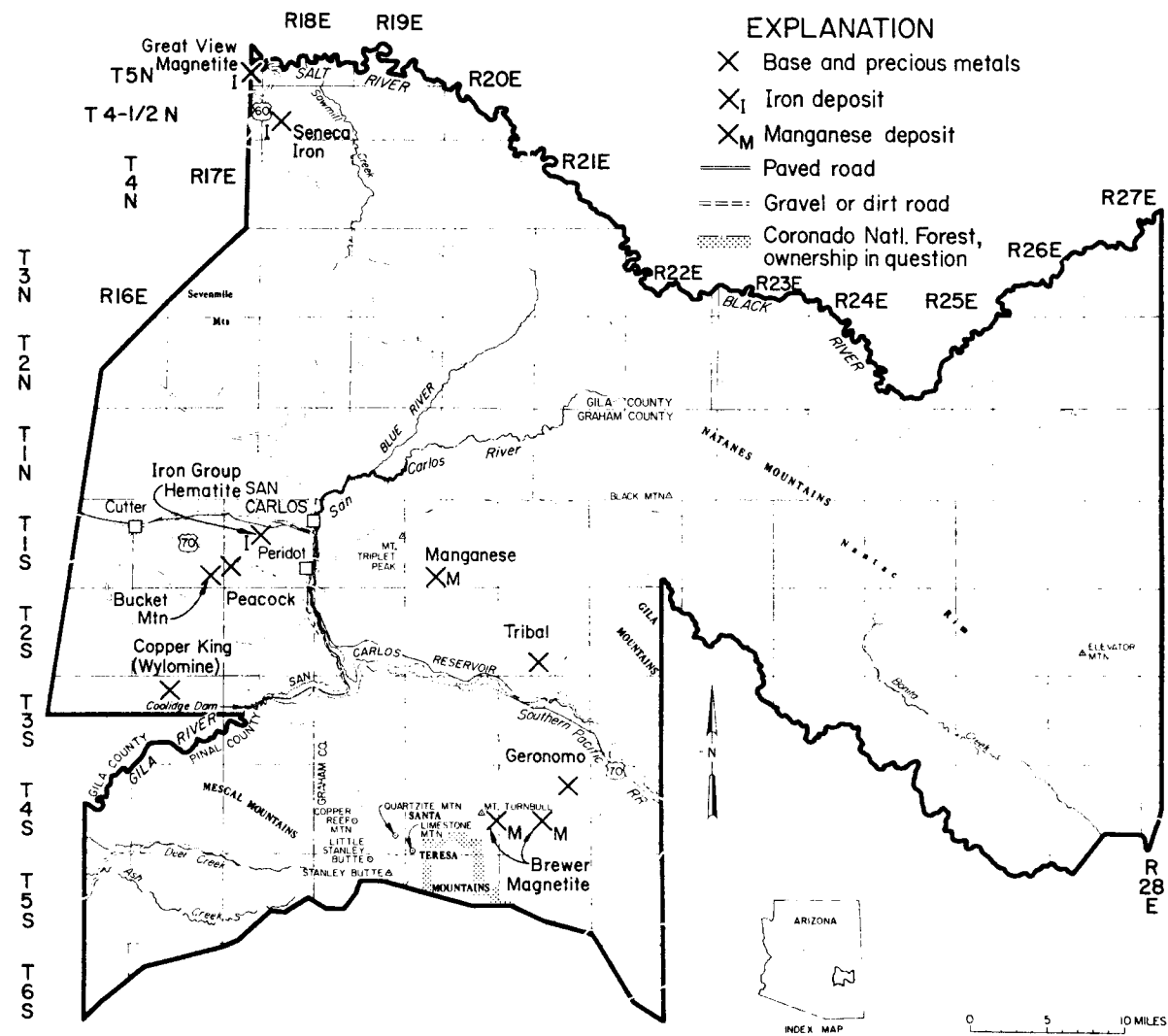
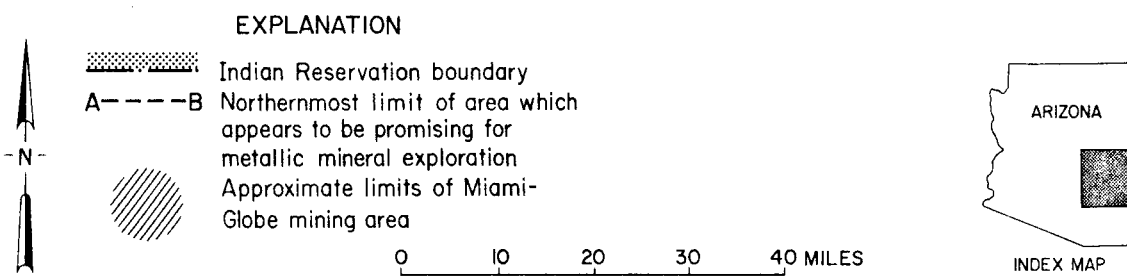
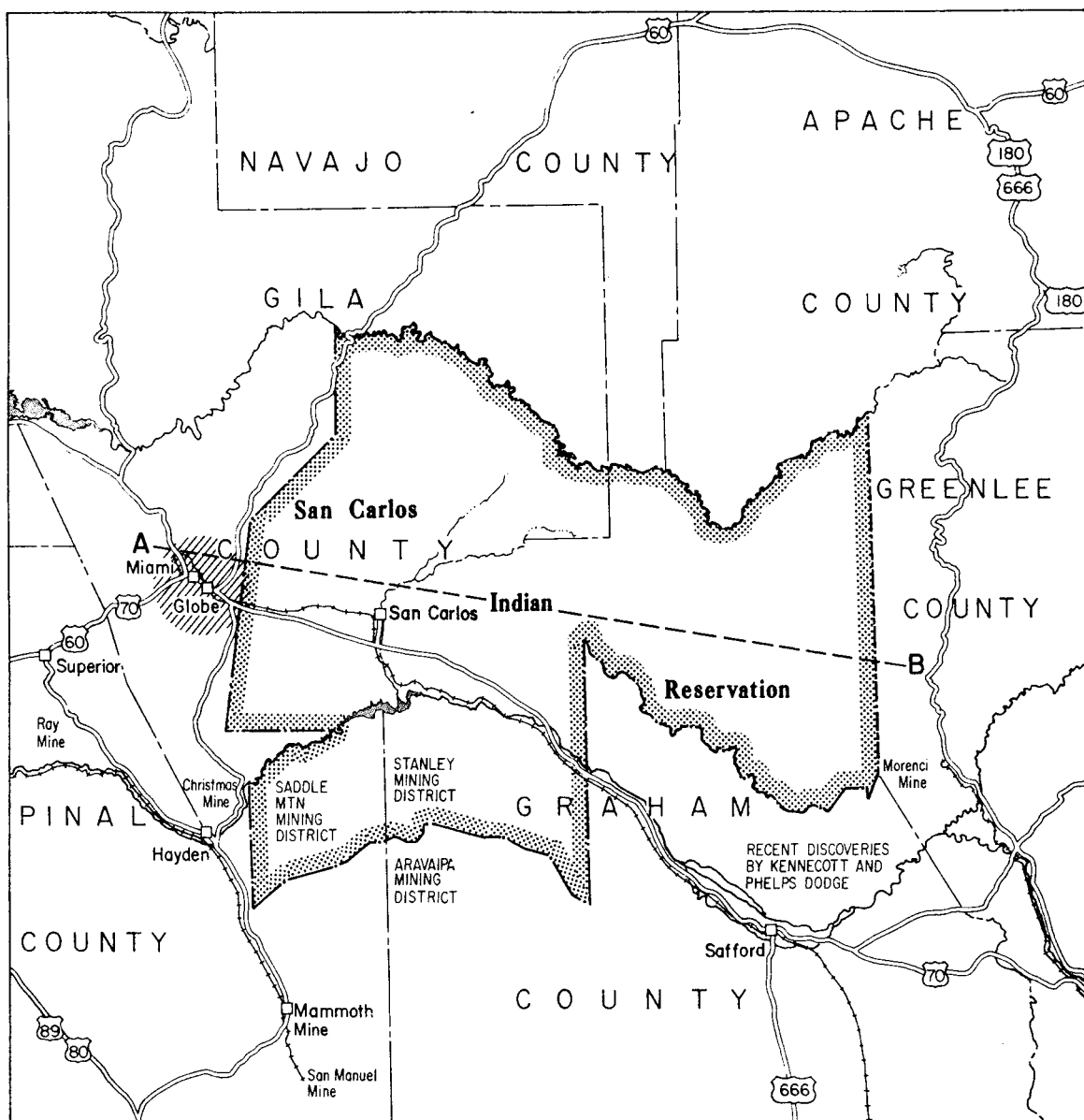
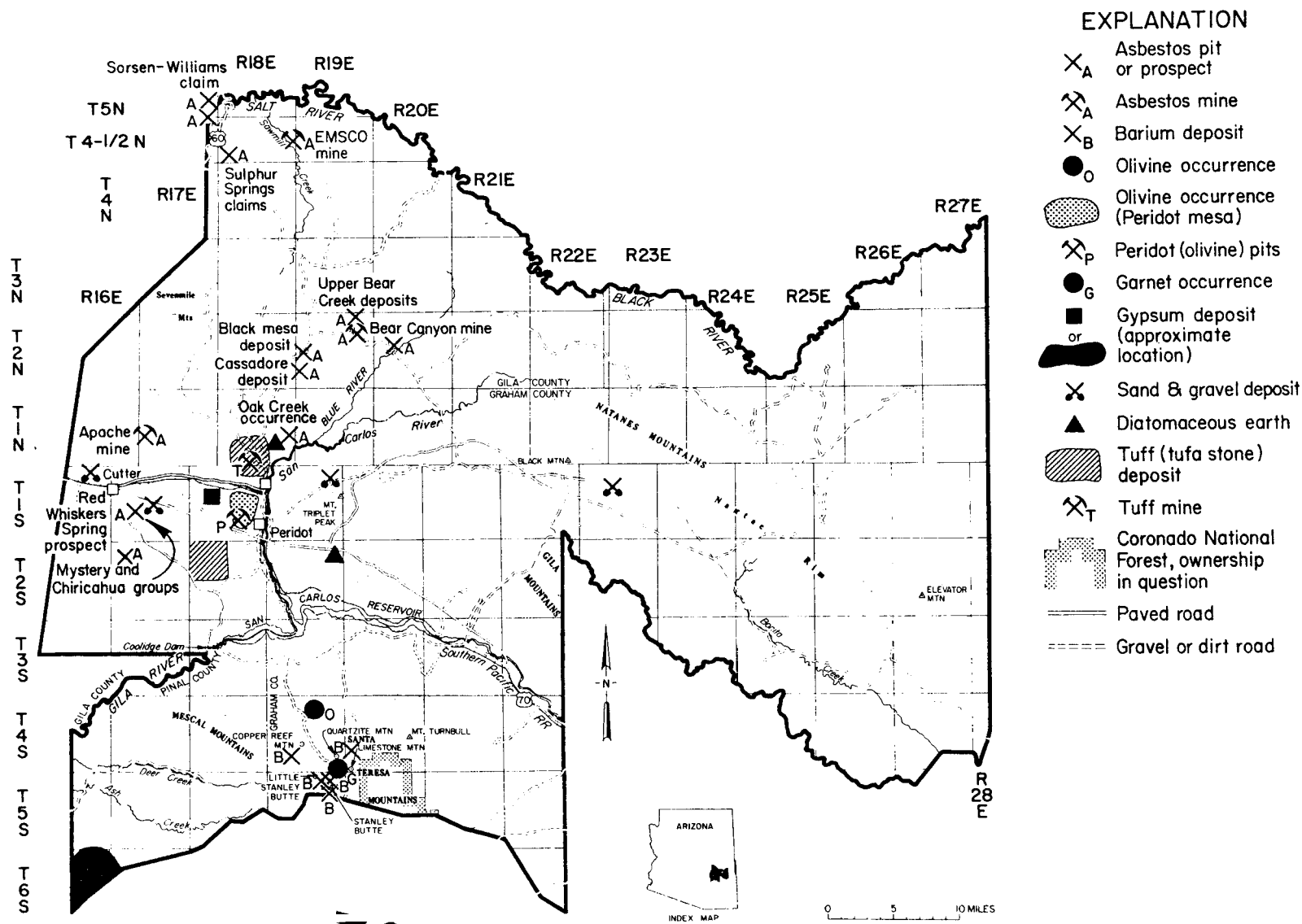


Figure 6. Metallic mineral deposits of the San Carlos Indian Reservation, Arizona.



**Figure 7.** Map showing the relationship of the San Carlos Indian Reservation to mines and mining districts in the region.



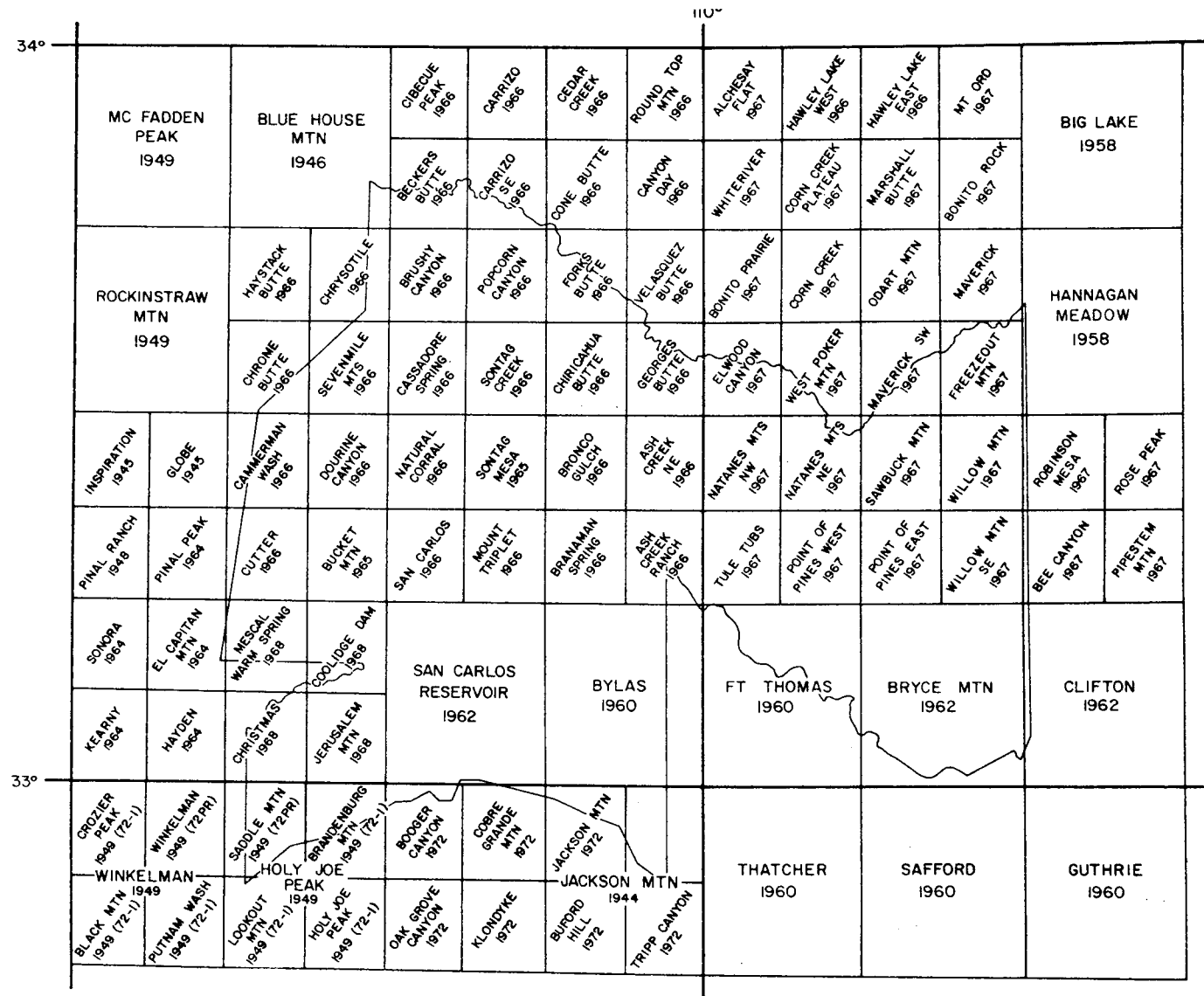


Figure 9. Topographic map coverage for the San Carlos Indian Reservation and vicinity.